UNIVERSITY OF OSLO
Department of Informatics

Unknown Pleasures: Designing for enjoyable user experiences

Rune Rosseland,
Snorre Berge

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Preface

This thesis has been written as a part of the master's degree 'Informatics: Design, Use, Interaction' at the University of Oslo.

First and foremost, we would like to thank our thesis supervisor Alma Leora Culén for her invaluable guidance, feedback and infectious engagement that made us push on. This engagement was not limited to 'office hours', seeing that she also made herself available at nights and weekends when needed, and volunteered to help us out with observation. We are extremely grateful.

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Abstract

In this thesis, we explore designing for enjoyable interactions with public installations based on body motion tracking . We also discuss evaluation of user experience related to such installations. The subject of user experience (UX) is sparsely researched, and its theoretical foundations and methodological approaches are highly debated. A central issue within this debate is the transferability and application of different theories and concepts from research to specific UX design and evaluation practices. Another issue is the application of theories to the study of UX in different use contexts. To tackle these problems, we decided to 'jump in at the deep end'. We set out to design an audiovisual installation that facilitated for enjoyable user experiences, without clearly defining our goals or methodological approach beforehand. We immersed ourselves in the subject matter throughout the design process by researching technologies, concepts, theories, and methods while doing practical design and testing of prototypes, thereby grounding our specific design process in relevant theoretical and methodological approaches. Our installation prototype has been evaluated in lab sessions with expert and amateur participants, as well as displayed in two public contexts. This work exemplifies how theories and methodologies can be applied to the practice of UX design and evaluation, and how different contexts can affect the user experience.

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Chapter 1

Introduction

Have you ever felt joy or pleasure through the use of interactive products? Real, positive feelings? Maybe you were listening to music and you suddenly discover an old favourite that you haven't heard for years. As you put it on, memories from the period starts flooding back. For a few seconds, or even minutes, you lose sense of time and space as your mind dwells on memories of the good old times you had.

Now, why did you feel this pleasure? Was the pleasure derived from the functionality of the music player? Or was it your own memories that made it an enjoyable experience?

1.1 Objective

The objective of this master thesis was to explore enjoyable user experiences through the design, implementation and evaluation of a publicly displayed interactive installation. This installation was used as a tool to investigate these qualities, how to design for them, and to explore how specific contexts affect the user experience.

1.1.1 Goals

Our goal was for the end users to have an enjoyable user experience, with focus on the experience for its own sake. Through an open ended system, focusing on playful exploration, we wanted to enable the participants to create and control their own experiences. This could be either on their own or in cooperation with other participants. We hoped to evoke feelings of pleasure among participants, captivate them and let them discover and explore the workings of the installation.

1.2 Motivation

1.2.1 Background

The original assignment connected to this thesis was quite loosely formulated, but in essence revolved around the topic of interaction design in conjunction with the emergence of the Kinect sensor and similar interfaces. The Kinect is a motion sensor, available as an add-on peripheral to the Microsoft Xbox 360 game console, and was designed to enable users to interact with game environments solely through bodily movements and gestures. Its widespread popularity was in part caused by the drivers and libraries that were developed and made publicly available by the 'hacker community', and later by Microsoft. This enabled Jane and John Doe to create their own applications using this technology.

From this starting point, we proceeded to shape our own assignment, based on personal and academic motivation.

1.2.2 Personal motivation

The main motivation for starting the work on this thesis was our fascination with the Kinect technology and excitement about new possibilities it introduced, as indicated by the vast range of experimental applications surfacing on the internet. Another motivating factor was that this assignment gave us an opportunity to get hands on experience with the technology and actually *create* something as a part of the thesis.

The title of this thesis, *Unknown Pleasures*, is a reference to the iconic Joy Division album with the same name, and is a play on words related to the topic of this thesis, namely our wish to explore enjoyable user experiences. The record cover of the Unknown Pleasures album is also iconic in its own right, and served as an inspiration for the abstract visual expression of the installation.

1.2.3 Academic motivation

The multidisciplinary field of *UX* (User Experience) is relatively new, and lacking in theoretical work [1]. Some researchers argue for the use of measurement models and structural models to develop a theoretical understanding of causal aspects user experience, which can be used to inform design [1]. Others argue for a more wholistic approach, where studies of real, situated use are used as the basis for the development of theories. We think this division is artificial [1]. Both approaches are important for a complete understanding of UX, and should be applied selectively depending upon the specific design context. In this thesis we try to combine the use of theoretical models of user experience with a wholistic and open-ended exploration of real-world use.

1.3 Problem area

1.3.1 Aim

The aim of this master thesis was to explore enjoyable user experiences through the design, implementation and evaluation of an interactive installation prototype, and to shed some light on how different public use-contexts influence the user experience.

A prerequisite for the installation was the use of a Kinect sensor as the interaction interface.

1.3.2 Research questions

1. **How to design and evaluate an interactive installation that facilitates for enjoyable user experiences?**
2. **How does different public use contexts influence the user experience?**

Chapter 2

Literature review

2.1 Three paradigms of HCI

The field of Human Computer Interaction (HCI) can be divided into three different paradigms: Human Factors, Classical Cognitivism/Information Processing and the Phenomenologically-Situated paradigm [2]. Human Factors simply tries to find useful and pragmatic ways to solve problems in the interaction between humans and machines. It is a pragmatic, problem-driven approach where usability-problems and challenges are tackled as they arise.

The classical cognitivism/information processing paradigm views the human *"mind and computer as coupled information processors"* [2, p.4] and the interaction between the two as signals of information. The signals affect the receiver in predictable and pre-determined ways, comprising a predictive, closed system of cause and effect. The role of HCI is to provide models for the different states possible within the relationship, enabling us to adjust the design in order to optimise the usability of the system, as in ease of use, ease of learning, effectivity, etc. It is also a problem-driven approach, but focuses on the construction of generalised models from specific cases that can be used to inform other cases. Objectivity and validity of data is central. The areas of attention are work processes and task completion. *"This cognitive-revolution-influenced approach to humans and technology is what we usually think of when we refer to the HCI field"* [2, p.4].

The third paradigm, the phenomenologically situated paradigm of HCI, has gained traction in recent years. It emphasises a range of more abstract and fuzzy factors that affect HCI, including dynamic use contexts, socially situated action, non-task oriented computing, emotions, etc. [2]. *"It focuses on the experiential quality of interaction, primarily the situated nature of meaning and meaning creation"* [2, p.1]. This paradigm seeks to produce 'thick', qualitative, subjective, and situated knowledge rather than objective and generalised design rules and models. *"The epistemological stance brought to this site is generally hermeneutic, not analytic, and focuses on developing wholistic, reflective understanding while staying open to the possibility of simultaneous, conflicting interpretation"* [2, p.13].

By focusing on the experiences people have, their wholistic and subjective nature, and how the use-context influences the experience, this thesis subscribes to the epistemological stance of the phenomenologically-situated, third paradigm of HCI.

2.2 UX

User experience (UX) as a concept and as a term is central to our project. It is very hard to define precisely, and there are a number of different ways of understanding and conceptualising it [3, 4]. It has gained in importance alongside the rise of the third paradigm of HCI, and further enhances the difference in approach between the second and third paradigms of HCI. The following section is a quick overview of UX as a term.

> *ISO 9241-210 defines user experience as "a person's perceptions and responses that result from the use or anticipated use of a product, system or service". According to the ISO definition user experience includes all the users' emotions, beliefs, preferences, perceptions, physical and psychological responses, behaviours and accomplishments that occur before, during and after use. The ISO also list three factors that influence user experience: system, user and the context of use.* [5]

Fundamentally, UX can be defined as a phenomenon, a research field, and a practice [6].

2.2.1 UX as a phenomenon

According to Roto et.al [6, p.6], UX is:

- *a subset of experience as a general concept. UX is more specific, since it is related to the experiences of using a system*
- *encounters with systems – not only active, personal use, but also being confronted with a system in a more passive way, for example, observing someone else using a system*
- *unique to an individual*
- *influenced by prior experiences and expectations based on those experiences*
- *rooted in a social and cultural context*

Furthermore, UX is not:

- *technology driven, but focuses on humans*
- *about just an individual using a system in isolation*

- *just cognitive task analysis, or seeing users as a 'human information processor'*
- *the same as usability, although usability, as perceived by the user, is typically an aspect contributing to the overall UX*
- *just user interface design*
- *brand/consumer/customer experience, although UX affects them and vice versa*

[6, p.6]

2.2.2 UX as a research field

UX as a research field is relatively new. Its origins are arguable, but UX has been a rising concern within the User Centered Design (UCD)- and HCI-communities since the early nineties [7]. But it is only really within the last decade that UX has come into existence as a research field in its own right [4]. UX research is concerned with studying user experience as a phenomenon, as well as developing and refining methods and techniques for UX- design, measurement, and evaluation [6]. It draws upon a wide variety of other research fields and practices, encompassing areas of psychology, physiology, ergonomics, social sciences, engineering, technology, arts, design, HCI, and UCD, among others [3, 8, 9].

2.2.3 UX as a practice

Parallel to the development of UX as a research field, user experience design (UXD) has also come into its own as a field of professional practice over the last decade. Businesses are increasingly realising the importance of experiential aspects to the success of interactive systems, and actively work to improve the user experience of their products.

> *The roots of user experience design (UXD) can be found in the principles of Human Centred Design (HCD; ISO 13407:1999; revised by ISO 9241-210), which can be summarised as:*
>
> - *Positioning the user as a central concern in the design process*
> - *Identifying the aspects of the design that are important to the target user group*
> - *Developing the design iteratively and inviting users' participation*
> - *Collecting evidence of user-specific factors to assess a design*
>
> [6, p.11]

2.2.4 Measurability of UX

The measurability of user experience is a central question for both researchers and practitioners of UX. Can human experience be measured? How can and should user experience be studied in order to produce understanding of the phenomenon? What kind of data is more useful for understanding user experience? The question, inherited from HCI, has divided the UX community into two distinct schools of thought.

Design-based UX The design-based approach advocates an understanding of UX as a complex, wholistic and subjective phenomenon that eludes quantitative measurement and analysis. According to this view, the only way to get a deep understanding of the experiential aspects of product use is through qualitative data gathering and analysis [7]. Common qualitative methods include: observation, open and semi-structured interviews, focus groups, future workshops, probes, collages, video and audio recording, thinking aloud and questionnaires, among others [7, 9, 10, 11]. It is argued that the data produced by these methods provide a depth of understanding of the subject that is impossible to obtain through quantifiable measurements. Indeed, qualitative UX research methods appear to be gaining in popularity compared to quantitative approaches [4, 7]. However, it has been pointed out that the use of questionnaires to produce quantifiable data is widespread within UX research [4, 7].

Model-based UX The model-based approach argues that experience is quantifiable, and that the application of measurement models provides a framework for precise and consistent measurement of user experience across different products and services. Also, structural models are used to examine and evaluate causal aspects of user experience, like precedent - antecedent and cause - effect, see [7].

> *[The qualitative, design based approach] assumes a richness in experience, which might not be that ubiquitous in everyday life. In addition, rich accounts of experience might require an outstandingly reflective and attentive 'experientor'. I suspect experiences with technology (as many other experiences as well) to be far less unique and far less variable as implied by the proponents of the 'phenomenological' approach: we all like to be challenged; we all like beautiful things, we all care about what others think about us and we all like romantic sunsets. Accounts of according experiences might differ in their quality, the experience itself does not. A poet may find beautiful words to describe her experience, this does not make it superior to what more mundane people experience.* [3, p.4]

Both approaches provide strong arguments for their case, and none of them are able to completely disprove the counterpart, indicating that a complete understanding of user experience needs to draw on the strengths of both. The data produced by the two approaches may be seen as complementary; they combine to form a more complete understanding of the subject [3]. Given the nature of the subject matter and the variety of perspectives on UX, it seems natural that the choice of methods should be based on the problem at hand. Also, the distinction between the two is not as clear-cut as it might appear. Qualitative data gathered systematically will, once transcribed and coded, be susceptible to quantitative statistical analysis [7].

Our approach to user experience can clearly be defined as design-based. We also agree with the wholistic and subjective understanding of UX, and argue that a complete understanding of users' experiences with products and services cannot be reached solely through quantified and measurable methods and models. However, our use of the *PLEX framework* is more in line with the model-based approach to UX. This framework provides a range of different aspects that influence playful user experiences, which we used to inform our design and evaluate our prototype. Nevertheless, we did not use this framework as a rigid structure through which we interpreted all our data, but rather as a place of departure for the exploration of pleasurable user experiences. The PLEX framework is described in more detail in section 2.6.2.

2.2.5 Factors affecting UX

As specified in the ISO 9241-210 standard, there are three main factors affecting UX: *Context*, *user*, and *system*.

Context

Users' experience with products and services are always happening within a context, or rather a number of contexts. First of all, experiences are situated within a geographic location, an environment. It can be inside, outside, on the beach, in the gym and so on. This environment will influence and shape the user experience. Secondly, social context is an important determinant for user experience. People are social animals and have a need to identify, relate, and belong to others [3]. There is a vast variety of social factors, both real and imagined, that will influence how we interact with and experience product use. This influences how we conceptualise and make meaning of the world. We even modify our understandings of experiences based on how those experiences are viewed by our peers.

Despite being generally acknowledged as important to UX, there is very little research done on how different contextual aspects affect UX [4].

User

The user is naturally central to the understanding of UX. Users bring a number of different concerns and understandings into product use situations. Depending on their previous experience with products, users will have more or less clearly defined expectations of what the user experience will be like. They also have certain needs and motivations for use, as well as interpretations of the meaning of their experience. Furthermore, users have differing mental and physical resources at their disposal, that will affect their experience as users.

Subjectivity of experience It is generally agreed the UX as a phenomenon is subjective [8, 6]. *"Experience itself is an ongoing reflection on events, [...] a constant stream of self-talk"* [3, p.1]. We continuously evaluate our current situation along a good/bad axis, seeking to maximise pleasure and minimise pain. However, our judgements can differ widely; what constitutes pleasure for some might be painful to others. Also, our needs and motivations may convince us to endure pain in the present to experience pleasure in the future, thus in some cases making the present pain enjoyable by substitution, just ask anyone who is passionate about exercise. Consequently, we can go through the same sequence of events and receive the same sensory input, but have quite different understandings and interpretations of the experience. Of course, the degree of variation is dependent on the nature of the experience, but some degree of subjective variation will always be present.

Hedonic vs pragmatic goals The distinction between hedonic (be-goals) and pragmatic (do-goals) aspects of user experience is common and useful. The terms are used to describe the two different but related dimensions of users' experiences.

> *Pragmatic quality refers to the product's perceived ability to support the achievement of 'do-goals', such as 'making a telephone call'[...] Pragmatic quality calls for a focus on the product – its utility and usability in relation to potential tasks. In contrast, hedonic quality refers to the product's perceived ability to support the achievement of 'be- goals', such as 'being competent', 'being related to others', 'being special' [. . .]. Hedonic quality calls for a focus on the Self, i.e., the question of why does someone own and use a particular product. Here, more general human needs beyond the instrumental come into play, such as a need for novelty and change, personal growth, self-expression and/or relatedness.* [3, p.2]

System

The characteristics of a particular product or service will naturally affect the user experience. Functionality and usability are important cornerstones of a pleasurable user experience. There is a complex and unresolved debate about the relationship between usability and UX [4, 6, 7, 8]. Despite of this, it is not difficult to agree that the two are connected. Poor usability produces confusion, frustration, and anger, all of which are antithetical to good user experiences. On the other hand, good usability alone does not guarantee a good or pleasurable user experience [12]. Thus, good usability and functionality can be thought of as prerequisites, but not causes for good UX. Other features of the product, such as interactive behaviour, aesthetics, meaning, etc., are more directly and positively contributing to the user experience.

2.2.6 Temporal aspects

A complete understanding of user experience needs to take into account how it changes over time. UX can be studied and evaluated along four main temporal dimensions: Before, during, and after use, in addition to cumulatively over time [6].

Anticipated UX A user experience usually starts before initial, actual use, and lasts long after the user has 'stopped' using the product. Before use we have anticipations of what use will be like, what it will mean for us. We have seen advertisements, read reviews, or heard friends talk about the product, and have certain needs and desires that we hope to fulfil through the use of the product. So we go into use-situations with preconceived ideas of what it will be like, and this will influence the way we make sense of the subsequent experience.

Momentary UX During actual use of the product we continually reevaluate our momentary experiences, and form episodic memories of what is happening. These momentary episodes are combined to form stories or narratives that describe the entire user experience.

Episodic UX After use we continue to reevaluate the experience both consciously and unconsciously. We use the remembered narrative to relive the experience and to share it with others. This re-evaluation enhances and suppresses different parts of the experience, and is also influenced by feedback from others, thus further developing our judgement and understanding of the experience.

Cumulative UX Finally, for a more complete understanding of users' experience with products over time it is necessary to do longitudinal studies where continuous product use cases are studied [13]. From personal experience, we know our relations to- and experiences of the products we use develop over time, and that they are influenced by a number of different factors throughout the lifecycle of the product. This presents serious methodological challenges like: Selection and recruitment of research subjects, how to collect data from people going about their daily lives and what data to collect, for example time, frequency, format, etc.

2.3 Experience and possibility design

The concepts of experience design and possibility-driven design are relevant for this thesis. Desmet and Hassenzahl [14, p.1] *"suggest possibility-driven design as an alternative to the common problem-driven approach"*. By this they mean that instead of focusing on problem-solving, to 'remove the negative', designers should focus on possibilities to improve people's lives in a positive way.

> *The transition from neutral to positive may require an approach beyond mere problem-solving. What we need are ways to address well-being directly through design and not only indirectly through the management of 'hygiene' or 'enabling' factors.* [14, p.4]

Hassenzahl [15] describes how the Philips *Wake-Up Light* turns the 'design-problem' of waking people up in the morning into a possibility to make a direct and positive impact in people's lives. This is a problem that has been 'solved' thousands of times through a vast array of different alarm clocks. But instead of simply using a loud sound of some kind, usually quite brutal, to tear people out of their dreams, the Wake-Up Light simulates a sunrise by gradually increasing the light half an hour before the person is supposed to wake up. It also uses the sounds of birds twittering as the alarm sound. This way the experience of waking up each morning is transformed from a gut-wrenching and sudden jolt, to a more gradual and harmonious fade into consciousness. Although it might not be effective for everyone, one can appreciate the potential this has to make a difference in someone's daily life.

We think this is a good way of approaching the design of good user experiences. It exemplifies the difference between usability and user experience. Good usability can be understood as the absence of *negative* factors that detract from the functionality of the product. It focuses on task-completion and elimination of problems. There are heaps of alarm-clocks with outstanding usability, but the Wake-Up Light goes beyond mere usability and attempts to turn an inherently unpleasant experience into something positive. Its design communicates an empathy and care for the user.

To seek happiness is one of the most fundamental and universal goals of all humans. But what is happiness? And how can it be designed for? The focus of our work is mainly on what Desmet and Hassenzahl [14] describes as *the pleasurable life*; happiness stemming from hedonic pleasures, the pursuit of good feelings and the pleasure of experience itself. This is contrasted to *the good life*, *"happiness that stems from the fulfilment through engaging in meaningful activity and the actualisation of one's true potential. This requires an ability to identify meaningful life goals, and to attain them."* [14, p.9] The pleasurable life is a direct and instinctive happiness connected to the experience itself, while the good life is a more meaningful and evaluative happiness stemming from the pursuit and attainment of goals.

Our installation focuses on *the pleasurable life*, and experience for its own sake. It does not solve a problem, nor does it aspire to help people reach meaningful life-goals. It seeks to provide an instant and viscerally pleasurable experience.

2.4 Enjoyment: Pleasure, fun and play

Fun, *pleasure*, and *play* are all related terms without a strong consensus concerning their definition. Their concepts overlap in parts, but at the same time they have some unique characteristics to them. In the following section we will attempt to shine a light on some of these.

2.4.1 Fun and Pleasure

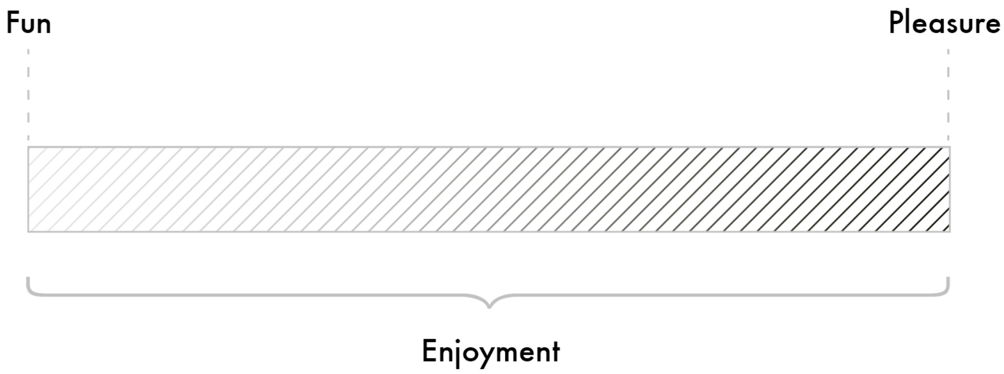

Figure 2.1: Fun and Pleasure as two extremes in the spectrum of Enjoyment.

By using *enjoyment* as an overall category, Blythe and Hassenzahl attempt an exercise of clearing up the semantics of pleasure and fun [16]. Enjoyment can be thought of as an experience fleeting somewhere between distraction and absorption, where on one end fun represents distraction and pleasure represent the absorption side of the scale (Figure 2.1).

The Oxford English Dictionary defines fun in the following manner: *"Diversion, amusement, sport; also, boisterous jocularity or gaiety, drollery. Also, a source or cause of amusement or pleasure."* [17], cited by Skinner [18].

In short, fun is described as the counterpart to seriousness. As a distraction it represents a spontaneous escapism from the tasks and worries of everyday life. The self, the hedonic 'be-goals' of UX, does not matter in this short-lived break from reality, but still it satisfies an important psychological need [16].

Pleasure is found on the opposite end of the enjoyment scale, taking on the role of absorption. It represents a deeper, longer lasting, more meaningful experience. Here the connection to people's inner self is made through immersion and devotion to an activity. Elements of challenge, progression and demand for absolute concentration can be present, and thereby overlaps strongly with Mihalyi Csikszentmihalyis concept of flow:

> *Being completely involved in an activity for its own sake. The ego falls away. Time flies. Every action, movement, and thought follows inevitably from the previous one, like playing jazz. Your whole being is involved, and you're using your skills to the utmost.* [19]

An important aspect of the experience of fun and pleasure is that they are indeed unique to every individual, but also highly context dependent. What was fun when you were a kid, might not be fun when grown up. Seeing a stand-up comedy show containing jokes with sexual content with friends might be fun, but watching it with your parents might be quite the opposite. Blythe and Hassenzahl also emphasise the difference between fun and pleasure by comparing having fun to the joy of repeating familiar patterns, while experiencing pleasure is compared to progressing: *"Instead of having fun by repeating familiar patterns, the pleasure-seeker will constantly explore new regions and domains in her pursuit of pleasure"*[16, p.98].

2.4.2 Play

Play is another fuzzy term to corner, as illustrated quite well by Brian Sutton-Smith [20, p.1] who has dedicated a whole book to this topic:

> *We all play occasionally, and we all know what playing feels like. But when it comes to making theoretical statements about what play is, we fall into silliness. There is little agreement among us, and much ambiguity.*

Although the term represents a myriad of experiences, it has been broadly described as *"free movement within a more rigid structure"* [21, p.304].

Bing Gordon, see [22], former Chief Creative Officer of game developer- and publishing house, Electronic Arts (EA), recalls that one of the driving forces behind the company in its early years was the belief that play is a core human value, comparing it to the play of lion cubs, preparing them for the real world without the risk.

Some of the most influential work on play is done by French sociologist Roger Caillois. He divides play into four forms and two types of play [23]. The four forms of play are competition, chance, simulation and vertigo, and these can occur on their own or in pairs, although certain combinations are considered unnatural or forbidden [24]. The two types of play Caillois distinguishes between are free play and formal play. They are considered two extremes of a spectrum and are named *paidia* and *ludus* (Figure 2.2). Paidia is considered the open-ended form of play or playfulness, where it does not necessarily have a defined beginning, end or goal. On the opposite end of the spectrum, ludus is considered to be more game-like, with winners and losers, clear rules and goals. An experience of play would then be placed somewhere on the axis between ludus and paidia [25].

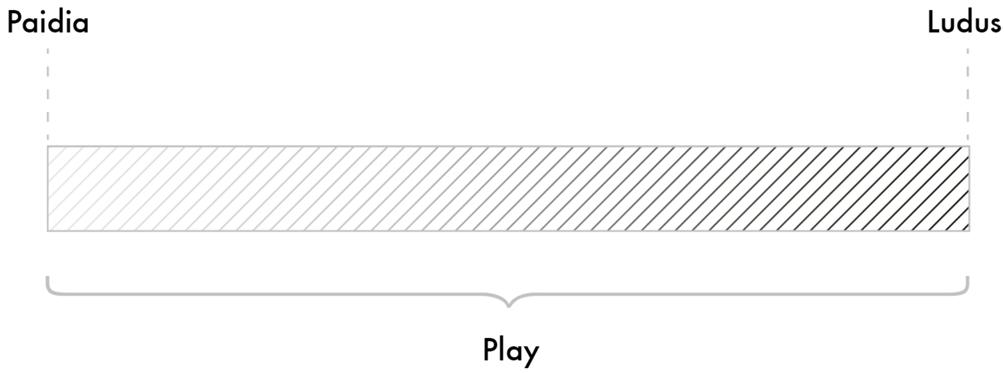

Figure 2.2: Paidia (free play) and ludus (game) as two extremes in the spectrum of Play.

In turn, *playful behaviour* is described as an oscillation between exploration and engagement [26]. Playful behaviour starts with exploration, and play occurs when the unfamiliar becomes familiar [27]. When the familiar gets boring, the focus returns to exploration. In this context, the goal of exploring is described as *"what can this object do?"* and the goal of play described as *"what can I do with this object"* [28], cited by Costello and Edmonds [29, p.108].

2.4.3 Enjoyment

As shown, the terms pleasure, fun and play are greatly intertwined, and are often used interchangeably by different researchers. For example, Csikszentmihalyi defines pleasure in a very similar fashion as Blythe and Hassenzahl describe fun: Pleasure is merely the feeling of being content when biological or social requirements have been met [30]. On the other hand his description of enjoyment leans closer to Blythe's description of pleasure:

> *"Playing a close game of tennis that stretches one's ability is enjoyable, as is reading a book that reveals things in a new light, as is having a conversation that leads us to express ideas we didn't know we had. Closing a contested business deal, or any piece of work well done, is enjoyable. None of these experiences may be particularly pleasurable at the time they are taking place, but afterward we think back on them and say, 'That really was fun' and wish they would happen again."* [30]

Regardless of which term is used to describe a concept, a difference exists between fun and pleasure. As emphasised by Csikszentmihalyi, and also pointed out by Blythe et.al.: Pleasure does not need to be fun and fun is not necessarily pleasurable. To complicate things further, even though play does not need to be pleasurable, Groos claims whenever *"an act is performed solely because of the pleasure it affords, there is play"* [31] (Cited by Costello and Edmonds).

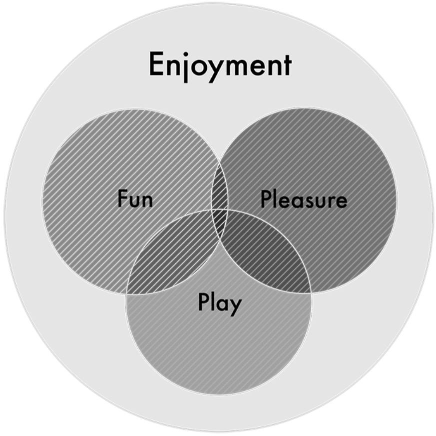

Figure 2.3: Fun, pleasure and fun as overlapping components of enjoyment.

In this thesis we will not strive to further distinguish between- and define these terms. From here on out we will instead use the umbrella term *enjoyment*. Enjoyment encompasses, in our opinion both pleasure, fun and play (Figure 2.3), and this will better suit the exploratory nature of our thesis. Their interlinked nature of the terms becomes quite apparent in this quote by Bill Moggridge:

> *People play to learn as well as to have fun, but they stop playing immediately if the toy or game gets boring. Toys and games are designed for enjoyment, to give rewards of pleasure and entertainment from the moment that they are first encountered to the day they are discarded.* [22]

2.5 Designing for enjoyable experiences

There are a plethora of resources available describing the philosophy around computer or video game design, but not as many concerning the design for interactive experiences in general. As our aim was not to design a game in its strictest sense, but rather explore the process of designing for an enjoyable experience, we will not dwell too much on the area of video game design in particular, since they often tend to lean towards the ludus-side of the Play-spectrum (Figure 2.2). Still, several aspects of game design are relevant for playful experiences in general, and we will here look at some of the ones relating to the goals of our experience. In his book *Designing Interactions* from 2006 [22], Bill Moggridge interviews several distinguished designers on the topic of play and creating successful games and toys. One of these is game designer 'superstar' Will Wright, who has created notable titles like the SimCity games, the Sims and Spore. Several of his titles has the characteristics of not being games that has a definite ending, meaning you can 'finish' them. Wright actually described SimCity to his publisher as *"... it's more of a toy, and less of a game"*[22, p.365], which aligns quite well with what we wanted to create. In this interview, Will Wright points to a few key factors to create a successful game:

Control over the experience Controls should be intuitive and easy to understand, or else frustration or boredom will occur in the manner of seconds.

> *The pleasure in playing a game is influenced by the structure of the feedback. When you first play a game, the very first thing you encounter is a five-second feedback loop between you and the computer, based on the control structure. The controls must be understandable to get you past that first potential barrier, and have to be fun to use or you will lose interest in the game. At each one of these interaction loops, you may succeed or fail.* [22, p.377]

Progression To make a game or interactive experience enjoyable over time, gradual progression is a key element.

> *We can learn from Will's explanation of how to engage the imagination of the players and build in a series of experiences that make them successful a little bit at a time, while keeping the path toward another step visibly open.* [22, p.380]

Open-endedness and goals As earlier mentioned, goals are important as a part of playful behaviour, but explicit goal definitions are not necessarily a prerequisite, since people tend to create their own goals and stories when the experience is of an open character.

> *With the Sim games, the options are much more open-ended and diverse. In SimCity, the game designer doesn't tell the player the exact goal. There is no instruction to build the biggest possible city in twenty years, or to make the residents happy. Each player decides what his or her goal is; that decision is as important as anything else that happens in the game.* [22, p.376]

It is still worth noting that the *for* in 'designing for enjoyable experiences' is important. An experience depends partly on what someone brings into a situation in terms of experience and taste. This means you cannot really design an experience, but at best *facilitate* for the experience to be enjoyable [32].

2.6 Tools for working with enjoyable user experiences

As one can see from the preceding section, the concepts of fun, pleasure and play have many common traits, and their definitions bleed into each other without distict borders. In this section we will look more into specific research done in the field of evaluating enjoyment in, and designing for interactive experiences.

2.6.1 The pleasure framework

The *pleasure framework* was developed by Dr. Brigid Costello, a lecturer in interaction design, and a practising digital artist. Her aim with the framework was to provide designers and artists with a tool, both to make them reflect more on the type of playful experiences they would want participants to experience, but also as something that could aid in the process of designing artworks or installations that involves playful behaviours.

The project of developing the framework was based on the hypothesis *"...that stimulating playful audience behaviour might be a way of achieving a deep level of audience engagement"* [26, p.77]. Costello emphasises that audience engagement and exploration of an artwork is necessary to experience it fully, and this was the reason why 'play' had a strong focus.

In her 2007 article, Costello describes the development of the framework, consisting of thirteen *pleasure categories of play*, based on the work of six theorists [26]. The categories of the pleasure framework and the concepts they build upon can be seen in figure 2.4, and a thorough examination of the work of the theorists and its relation to the framework is the subject of Costello and Edmonds' article from 2009 [24]. The theorists in question were philosophers Karl Groos and Roger Callois, the psychologists Mihaly Csikszentmihalyi and Michael Apter and the game designers Pierre Garneau and Marc LeBlanc.

Groos	*Callois*	*Csikszent'*	*Apter*	*Garneau*	*LeBlanc*	**Framework**
Pleasure of being a cause				Power Creation	Expression	**Creation**
			Exploration			**Exploration**
		Problem Solving		Discovery Intellectual problem solving	Discovery	**Discovery**
			Challenge	Application of Skill	Challenge	**Difficulty**
	Competition	Competition		Competition Advancement & Completion		**Competition**
	Chance	Risk & Chance	Facing Danger	Thrill of Danger		**Danger**
				Immersion Beauty	Submission	**Captivation**
	Vertigo		Arousing Stimulation	Physical Activity	Sensation	**Sensation**
Aesthetic sympathy						**Sympathy**
Pleasure of make believe	Simulation	Creative	Fiction & Narrative		Narrative	**Simulation**
					Fantasy	**Fantasy**
		Friendship & Relaxation		Love Social Interaction	Fellowship	**Camaraderie**
			Negativism Cognitive Synergy	Comedy		**Subversion**

Figure 2.4: An overview of the classification of emotion by the six theorist, and the final categories of the *pleasure framework*. (Table from "A Study in Play, Pleasure and Interaction Design" by Costello and Edmonds [26])

Test framework usefulness The framework was tested through applying it to a selection of 30 existing works considered successful, to validate and refine the categories. It was then applied in the design process of three different artworks.

For two of the artworks, the framework was applied during evaluative reflections and for the last creation it was used during the whole design process. When evaluating the work, participants using the artworks were recorded on video. Afterwards they were interviewed while they reviewed their previously recorded experience and proceeded to explain their thoughts and emotions during the experience. During the interview, the participants were asked to complete a survey, identifying which of the 13 categories defined in the framework they experienced.

Costello found the pleasure framework survey helpful in terms of identifying discrepancies between audience perceptions and artist's aims. Particularly concerning the first artwork of the three, where she felt the artwork needed more work, but where the user evaluation showed surprisingly high scores for the categories *sensation* and *creation*.

The high position given to the category *camaraderie* was interesting because it confirmed a tendency noted during the evaluation sessions for pairs to engage more with each other. In their comments some participants said that they particularly enjoyed experiencing this work with their partner.

These results suggested that the pleasure framework could be both an effective tool for the conceptual design of playful interactive art and a useful addition to formal user evaluations of this type of work. A notable point is that the framework was also effective in giving interviewer and participant a common language for discussion. Costello emphasises that when the framework is applied to an artwork, the success of the work should not be based on an expectation to score high in all categories. In her case, there seemed instead to be a trend of two or three categories becoming the predominant ones.

2.6.2 Playful Experience framework (PLEX)

The *PLEX framework* was developed by Hannu Korhonen, Markus Montola and Juha Arrasvuori and is basically an expansion of Costello and Edmonds' pleasure framework [26].

Korhonen et.al. thinks the pleasure framework is a great starting point, but that it may be best suited for designing and evaluating interactive art. Their goal was to expand on the previous work to better suit it to a more general category of playful experiences, by learning from studies of video gaming.

While Costello and Edmonds acknowledge that a positive user experience can also consist of negative emotions, their framework focuses mainly on *playful pleasures*. Korhonen states that the focus of the PLEX framework will instead be on *playful experiences*, since experiences like this will not necessarily be pleasurable. The goal of their extended version of the framework was, as expressed by the authors: *"Our interests are in the broader domain of playful experiences, and in particular, in how to design utilitarian products that elicit playful experiences"* [25, p.278].

The main alterations to the pleasure framework was by adding seven new categories to the thirteen already present by Costello and Edmonds (Figure 2.4). Three categories were also renamed to better fit the general concept of play. *Danger* was changed to *Thrill* with the reasoning that real danger is seldom felt when playing. *Camaraderie* was changed to *Fellowship* and *Creation* to *Expression*, both to broaden the applicable areas for these categories.

The new categories added by Korhonen et. al. were initially *Control*, *Nurture*, *Completion*, *Sadism*, *Submission* and *Suffering*. Submission was later removed on the basis of their experiment lacking participants reporting on this category of emotion. Furthermore, two new categories, *Eroticism* and *Relaxation*, were added after being reported by participants. It resulted in these final categories and descriptions [25]:

Category	Description
Captivation	Experience of forgetting one's surroundings
Challenge	Experience of having to develop and exercise skills in a challenging situation
Competition	Experience of victory-oriented competition against oneself, opponent or system
Completion	Experience of completion, finishing and closure, in relation to an earlier task or tension
Control	Experience power, mastery, control or virtuosity
Discovery	Experience of discovering a new solution, place or property
Eroticism	Experience of sexual pleasure or arousal
Exploration	Experience of exploring or investigating a world, affordance, puzzle or situation
Expression	Experience of creating something or expressing oneself in a creative fashion
Fantasy	Experience of make-believe involving fantastical narratives, worlds or characters
Fellowship	Experience of friendship, fellowship, communality or intimacy
Nurture	Experience of nurturing, grooming or caretaking
Relaxation	Experience of unwinding, relaxation or stress relief. Calmness during play
Sadism	Experience of destruction and exerting power over others
Sensation	Meaningful sensory experience
Simulation	Experience of perceiving a representation of everyday life
Subversion	Experience of breaking social roles, rules and norms
Suffering	Experience of frustration, anger, boredom and disappointment typical to playing
Sympathy	Experience of sharing emotional feelings
Thrill	Experience of thrill derived from an actual or perceived danger or risk

For our thesis, we decided to go with the PLEX framework in favour of the pleasure framework, although the conduct of our prototype evaluations had more in common with how Costello described hers [26]. One reason for our choice of PLEX as a tool was the claim of Korhonen et. al. to have expanded the framework to be suitable for a more general use than just interactive art. The second and most important reason was that the PLEX framework included categories covering the negative aspects of enjoyment, like subversion, suffering and sadism.

Chapter 3

Methods

3.1 Research approach and methodology

3.1.1 Qualitative research methods

> *Qualitative research methods are designed to help researchers understand people and the social and cultural contexts within which they live. [...] The goal of understanding a phenomenon from the point of view of the participants and its particular social and institutional context is largely lost when textual data are quantified.* [33]

Given the subjective nature of experience, and our phenomenological, design-based approach to the problem area, we will primarily be relying on qualitative research methods. Qualitative methods are well suited to produce rich, intersubjective, and wholistic understandings of human experience.

3.1.2 Research paradigm

Qualitative research, and indeed all research, can be divided into three epistemological paradigms: *Positivist*, *interpretive*, and *critical research* [33]. These have important implications for the kind of knowledge the research can be expected to produce, and what kind of methods are deemed appropriate.

Positivist research

According to Myers [33], *"Positivists generally assume that reality is objectively given and can be described by measurable properties which are independent of the observer (researcher) and his or her instruments"*. This is the kind of research most commonly associated with the natural sciences and includes hypotheses testing, controlled and replicable experiments, and inferences from sample cases to whole populations [33]. We acknowledge that there are ways of applying an objective and positivistic approach to the study of user experience. As Hassenzahl [3] has suggested, human appreciation for beautiful things and romantic sunsets is relatively universal, and while our user experiences with a particular product can differ in their quality or intensity, the experiences themselves are relatively homogenous.

Interpretive research

In interpretive research, on the other hand, there is no objective reality to study and discover.

> *Interpretive researchers start out with the assumption that access to reality [...] is only through social constructions such as language, consciousness and shared meanings. The philosophical base of interpretive research is hermeneutics and phenomenology.* [33]

By interpreting the phenomena we encounter we form understandings of them, and use these understandings to interpret subsequent similar phenomena and experiences. In this way we continually and iteratively refine our understandings of reality. This applies to humans in general, but also to researchers doing interpretive research. *"Interpretivism is [...] an epistemological position, concerned with approaches to the understanding of reality and asserting that all such knowledge is necessarily a social construct and thus subjective"* [34, p.5].

Critical research

Critical research also understands reality as socially constructed, *"produced and reproduced by people"* [33]. However, the focus is on how this socially constructed reality has developed throughout history as a form of social, cultural, and political domination. *"The main task of critical research is seen as being one of social critique, whereby the restrictive and alienating conditions of the status quo are brought to light."* [33].

Our approach Applying a positivist research paradigm in our experimental design context makes little sense, since our thesis is not about finding quantifiable truths about user experience, nor is it about creating generalised models of user experience. We are also of the opinion that critical research is an inappropriate research paradigm for our thesis, as we have no ambitions of social critique or any emancipatory effect of our work. We are in business of exploring enjoyable user experiences. Given our intentions, and the subjective and phenomenological nature of user experience, we feel that the only fitting epistemological stance for our thesis is the interpretive paradigm.

3.1.3 Methodology

Grounded theory is an inductive research methodology well suited for interpretive research. It emphasises the importance of grounding theory in empirical data [35]. In contrast to the positivist approach of hypothesis development and testing, where the tests are conducted to prove or disprove a predefined hypothesis, grounded theory starts with empirical observations and data, and tries to develop theories from this basis.

> *Grounded theory is both a theory and a methodology. As a theory, it is the* result *when one's empirical material is analysed and structured*

> *according to grounded theory procedures. As a methodology, it is the* procedures and techniques *that help generate grounded theory from one's data* [36].

Grounded theory research seeks to identify patterns in the data and develop theories through a continuous interplay between data gathering and data analysis. Through open and axial coding, concept development, and grouping of concepts into categories, the theory is allowed to emerge [36, 35]. Thus, the developed theory can only be explained or justified with reference to how it relates to the specific use context, and is therefore not seen as universally transferable to other use contexts.

This methodology suited our qualitative and interpretive research agenda. We wanted to explore enjoyable user experiences through the design of an interactive installation. The only purpose of the installation was to provide users with *an experience*, thereby providing us a specific system and a specific use-context to study. By grounding our theory development in observations and data gathered from the use of the installation, we attempted to gain some insights into the constitution of enjoyable user experiences and how those experiences are affected by the specific use context. Still, it is important to point out that by using the PLEX framework as a point of departure throughout the design and evaluation of our installation, we applied an external theoretical structure, or model, to our research. This is conflicting with a strict understanding of the principles of grounded theory. Nevertheless, the PLEX framework was not used in the data analysis. Instead, the gathered data was coded and organised into categories and themes that emerged from the data itself, thus being more in line with the principles of grounded theory.

3.2 Research methods

3.2.1 Observation

Participant observation *"Participant observation is the core means by which ethnographers have tried to [...] understand the worldviews and ways of life of actual people in the contexts of their everyday lived experiences"* [10, p.37]. It implies that the researcher gets involved in the lives and activities of the research subjects on equal terms, and tries to create intersubjective understandings of their experiences [10]. This is an opportunity for the researcher to immerse him or herself in the subject matter in a way that is impossible through more conventional methods like interviews or questionnaires.

Passive observation Passive observation, on the other hand, is not about the researcher getting involved, but rather about being a fly on the wall. This kind of observation is more akin to the objective and detached natural scientist observing animals in their natural habitat. The purpose is to be able to observe people going about their business in *their* 'natural habitat', without disturbing them or their environment in any way. Depending on the area of investigation, gaining access to observe people without them being aware of it can be difficult, or even impossible.

Lab studies Somewhere in-between the extremes of participant and passive observation are lab studies of different kinds, where the research subjects are invited to take part in controlled experiments. In this case, the participants are aware that they are being observed but are asked to ignore this and behave as if they were alone. One-way mirrors and audio and video recording are commonly used to reduce the perception of being watched.

Note-taking Note-taking is a central element of observation [10, 35]. Without note-taking there will be no way of documenting or reviewing the observed events after the fact. However, the task can quickly become overwhelming, as the amount of data it is possible to record is enormous. It is also very difficult to observe properly while taking detailed notes.

Preparation In preparing for observation and note-taking it is important to think through the subject matter and have a clear understanding of the intention and purpose of the observation. This is to avoid getting overwhelmed by the amount of information it is possible to record, but rather focus on what is important. Defining a set of shorthand codes for important information to observe will speed up the process of note-taking and make it possible to gather more data in the same amount of time.

Reflection of roles and interests Lastly, it is important to reflect on the roles and interests of the observers. As easy as it may seem, observing objectively is arguably close to impossible, as every observer carries a certain set of preconceptions and convictions of the subject matter [35]. As mentioned earlier, participant observation is more about creating intersubjective understandings than strict objectivity, while passive observation can be thought of as more objective.

Our approach In our fieldwork we conducted mostly passive observation when studying how people interact with the installation in a public setting. However, during our exhibition at the Oslo Mini Maker Faire we were required to be available to answer questions from the public and explain how our installation worked, as this was expected of us as exhibitors. This resulted in us actively participating alongside the visitors and talking and interacting with them while using the installation. Participant observation assumes the existence of a community of practice, which does not exist for our experimental design context. In this situation, our thesis supervisor stepped in, helping us by doing passive observation for a time during the exhibition. In addition, we have conducted several informal, 'quick-and-dirty' user tests with prototypes to observe how people interpret different design ideas, as well as more organised lab-tests of the finished prototype where we observed, filmed, and interviewed pairs of users interacting with the system.

3.2.2 Interview

Beyond merely observing people, interviewing is the most common ethnographic method [10], and for a good reason. Asking questions is central to how we as humans communicate knowledge and learn from each other. We ask questions as soon as we learn how to speak, and we continue to do so throughout our lives. Interviews can range from the strictly controlled, to loose conversations, but are generally divided into three different categories: *Structured*, *semi-structured*, and *open-ended* [10].

Structured Structured interviews are, as the name implies, structured and tightly controlled, and are normally used to produce data for statistical analysis. By asking a large number of people a predetermined set of questions, and limiting the range of valid answers, it is possible to produce statistically significant data through structured interviews [35]. It can also produce more open-ended and qualitative responses, depending on the subject of inquiry. However, deviations from the script are not permitted. This ensures that each interviewee is asked the same set of questions, making the data easy to compare and analyse. But strict adherence to a predefined script can result in important and relevant data being lost because there is no room to pursue questions not included in the script [35].

Semi-structured Semi-structured interviews are also based on a predetermined set of question, but allow for deviations from the script if the interviewer feels that the topic under discussion is relevant for the subject at hand [10, 35]. Also, semi-structured interviews put less restrictions on the range of possible answers. Where a structured interview could be based on a questionnaire with predetermined answers, a semi-structured interview typically requires the interviewee to formulate his or her own answers to the questions posed. This puts more demand on the interviewer to document the answers given, either through careful note-taking or audio recording.

Open-ended Open-ended interviews are more like loose, informal conversations on a given topic [10, 35]. Again, due to the uncontrolled nature of the interview and the lack of a predetermined set of questions, this also demands extensive note-taking, or more preferably, audio or even video recording. While structured interviews rely on questioning many people to produce enough data for statistical analysis, open-ended interviews are more one-off events that are difficult to reproduce or repeat in a controlled way. Consequently, open-ended interviews are better suited for initial, explorative interviews with domain experts rather than for repeated interviews with a large number of people. Also, the data produced are for all intents and purposes qualitative in nature. Semi-structured interviews are, of course, somewhere in-between structured and open-ended and can produce both qualitative and quantitative data.

Our approach In our phenomenological and explorative design context, fully structured interviews are ill-suited as a data-gathering method. We simply would not be able to explore the topics fully, and severely limit the usefulness of the data. In addition, we would have to conduct significantly more interviews in order to have enough data for statistical analysis. We chose instead to use semi-structured interviews during our prototype evaluation sessions. This allowed us to prepare a list of questions and topics that we wanted to make sure was covered during the interviews, while still being able to explore any interesting topics that arose during the conversations.

3.2.3 Audio recording

Audio recording of interviews can be a good way to lessen the cognitive load on the interviewer or other note takers. This allows the interviewer to focus their note-taking on important elements in the conversation rather than worry about faithfully noting every spoken syllable. It also frees the interviewer to observe body language and other forms of non-verbal communication, as well as being more attentive and present in the conversation with the interviewee.

Transcription However, audio recording can be a blessing in disguise. All recorded audio needs to be transcribed and coded, and this can become prohibitively time consuming. An hour of interview typically takes at least two hours of transcribing, and with several interviews the task can quickly feel insurmountable.

Recording quality It is also very important to ensure that the quality of the recorded audio is as good as possible: Use proper recording equipment, minimise external/ambient noise, minimise the distance between microphone and sound source(s), and avoid placing the microphone in places where it can be covered or bumped. By heeding these rules the time spent transcribing will be less painful and time consuming.

Our use We have recorded audio from all our interviews, as this allowed us to be a lot more attentive and present during the interviews than we otherwise would have been, and also let us accurately transcribe the interviews later, in our own time.

3.2.4 Video recording

Video recording can to a certain extent reduce the need for extensive note-taking during observation, but is important to remember that video is two-dimensional and has important technical limitations to the level of detail that can be recorded. Also, video recordings must eventually be reviewed and transcribed in order to have any utility in a research context. All the same considerations given for audio recording also applies to video recording. If the video camera is used to record both sound and video, it is easy to forget that the camera microphone needs to be as close as possible to the sound source(s) in order to record usable audio. Not remembering this can have disastrous implications for the usability of the recorded material.

Richness of data A benefit of using video (and audio) recording over only audio is that it also records body language, gestures, facial expressions, etc. which can be useful in deciphering more subtle nuances or attitudes in answers given by the interviewee.

Our use We used three video cameras to cover all relevant angles during our lab-evaluations. One covered the screen of our installation, documenting the visual output of the system. Another was put in front of the screen, facing out into the room, documenting the participants interacting with the installation. We also used a third hand-held camera which shifted focus depending on what was going on. These videos have been of great use for us in analysing, coding, and conceptualising the experiences people have with our installation.

3.3 Design methods

This section present the methods used in the process of designing our installation and in the execution of the private and public experiments. It will give a brief introduction to the methods used and why they were applied in the process. A more in-depth description of how the methods were utilised will be found in the Design Process chapter (Section 4).

3.3.1 Prototypes

Prototypes are a vital part of designing and exploring the possibilities of an interactive computer system. The definition of a prototype is, according to Houde and Hill, "...any representation of a design idea, regardless of medium. This includes a pre-existing object when used to answer a design question" [37]. Prototypes are often divided into two rough categories: *Low fidelity* and *high fidelity*.

Low fidelity prototypes

Low fidelity prototypes are often used to quickly explore ideas early on in the design process. They serve as both proofs of concept and useful communication devices towards users or within the design team. Low fidelity prototypes are often cheap and fast to build, enabling fast iterations and are never intended to be included in the final product [9]. Examples of low fidelity prototypes are storyboards, sketches, mock-ups and rough models.

High fidelity prototypes

High fidelity prototypes on the other hand are more complete prototypes that are fully interactive and with complete functionality [9]. This makes them more time consuming and costly to produce, but also make them better suited for testing by users.

Our use In our case the use of prototyping were crucial and both high and low fidelity prototypes were used extensively. Early ideas were first mapped out as thumbnail sketches on paper and served as talking points in brainstorming sessions. Because of our lack of intimate knowledge of the Kinect sensor, we needed to thoroughly explore the technological possibilities and limitations and its available

API libraries. To achieve this knowledge, we developed a range of small high fidelity prototypes to test the technology, possible interaction forms and audiovisual expressions. Some of these early prototypes were in turn incorporated as parts of the final prototype.

3.3.2 Brainstorming and mind maps

Brainstorm

Brainstorming is a creative technique often used in advertising for generating ideas or solutions to a problem, developed by Alex Faickney Osborn [38] in the fifties. It originally based on a hypothesis that a group is more effective in generating ideas than individuals, and consists of two main principles: *Aim for quantity* and *withhold criticism*.

These were again divided into four more rules [39]:

- *Criticism is ruled out.*
- *'Free-wheeling' is welcomed.*
- *Quantity is wanted.*
- *Combination and improvements are sought.*

Brainstorming can be a powerful technique to empty the mind of ideas and associations concerning the subject at hand, and generate as many ideas as possible while in the brainstorming process. All ideas should be recorded, enabling designers to revisit them at later stages to discover previously overseen angles, or see earlier associations spark other thoughts to solve the problem at hand. An essential part of the brainstorming process is that there are no bad ideas, no matter how far fetched they might seem. The point is to get all the ideas out in the open [40]. The distillation and selection of ideas comes at a later stage.

The notion that groups are more efficient in generating ideas than individuals has been criticised, most notably by Wolfgang Stroebe and Michael Diehl [39]. They argue that individuals should rather create ideas on their own and use group sessions only for evaluation. Furthermore, *if* brainstorming is used as a technique, it should be done in as small groups as possible.

Mind maps

The term mind map were popularised by Tony Buzan in the early nineties [41], and are tree-like or 'spider-web' diagrams often used in brainstorming sessions. In a mind map hierarchies and associations flow freely outwards from a central image or word describing the topic of the brainstorming [42]. Major topics are connected in close proximity to the central theme and more peripheral topics are further out. Mind maps are used to visualise, classify and structure ideas, and can be used at later stages to review trains of thought and stimulate additional associations.

Our use Both mind maps and brainstorming were used as methods to generate ideas in the development of a concept for the final installation and during the later stages when designing the prototype's different modes of operation. We acknowledge the criticism by Stroebe and Diehl that brainstorming can be vulnerable to group dynamics, but we argue that any group based activity can be victim to this. We chose to use brainstorming as a technique to leverage the combination of ideas, and the power of association and collaboration when developing a concept we both have considerable stakes in.

3.4 Ethical considerations

It is important to respect the privacy of any research participant, and to make sure that the data collected is stored and organised in a way that does not compromise the privacy of any of the participants. Research participants in Norway are protected by *Personvernombudet for forskning* [43], which publishes guidelines for how to collect personal and sensitive information during research. First and foremost, participation must be explicitly voluntary and informed. Participants must be informed about:

- Which institution is responsible for the research.
- The researchers' contact details.
- The purpose of the project, and how the information will be used.
- That participation is voluntary and that the participant can terminate his or her involvement at any time, without any explanation.
- How the information gathered will be treated once the project is finished (erased/anonymised, or stored).

The participants of our lab-evaluations were all asked to sign informed consent forms prior to participation, detailing the necessary information and stressing the voluntary nature of their involvement. The participants observed interacting with the installation in public never disclosed any personal information, and were not identifiable in any photos.

Chapter 4

Design process

4.1 Intention

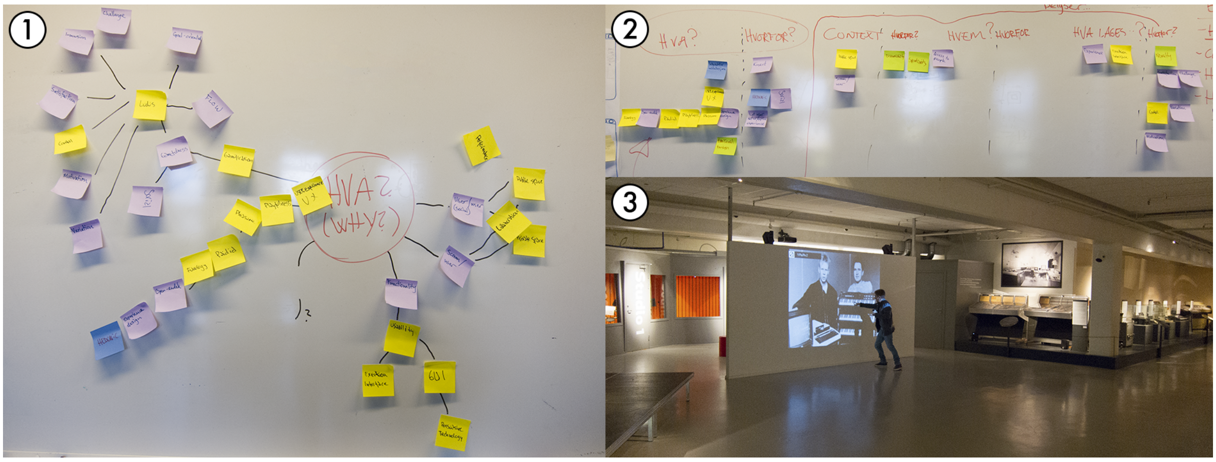

Figure 4.1: (1) Mind mapping our intentions for the installation. (2) Using card sorting to discuss and clarify our intentions. (3) Location scouting for public exhibition space.

Before describing our design process it is necessary to clarify the intentions of our design. These intentions were developed over time and involved a string of discussions and brainstorming sessions ((1) and (2) Figure 4.1), resulting in the goals stated in the introduction (Section 1.1.1).

Most 'designed' things have roots in some kind of problem or challenge that needs to be resolved, and the design can be seen as a solution to the problem. Our installation, on the other hand, is rooted in a desire to research designing for positive user experiences involving Kinect sensors as interface. The installation does not have any specific purpose or utility outside of our research context. This is important to have in mind as we go into the specifics of the design process. In many ways the installation could be considered an interactive art piece, adhering to the point made by Brigid Costello:

> *Much interactive art focuses on producing an experience together with audience participants and 'getting it', in the sense of understanding a message, is not really the point.* [26, p.77]

At the outset of the project we had only a very broad idea of what we wanted to create. As we did not have a specific goal in mind or a problem to solve, refining this idea was a process that stretched over months. This also meant it was hard to conduct a traditional participatory design process, as we did not yet know what we were about to create. This conundrum was also described quite well by the designers of the V Motion project: (Section 4.4.1:

> *The final design of the machine was the result of months of experimenting... it all makes perfect sense in hindsight, but in the beginning, none of us were really sure what we were building.* - V Motion project [44]

Given the Kinect's ability to identify and track multiple users, we wanted to build an installation where several people could use it simultaneously, thereby introducing a social element to the interaction. But it was important to us that the installation also should be possible to use alone. We were clear that we did not want to design a 'computer game' in any traditional sense of the term, but rather an experiential system where the users are 'free' to shape and develop their own experiences. Lastly, in order to create an experience as immersive as possible, we wanted the installation to produce both sounds and visuals in some form in response to user's movement. As aesthetics is an important aspect of user experience, it was also a high priority for us. Both in terms of audio and visuals, and that the two expressions should coexist seamlessly to create a unified sensory experience.

Given the art-like nature of our installation, we thought it best fitting in a public context. We imagined it could be on the street, in a shopping center or in a museum or gallery, acting as a diversion from the ordinary and giving users a silly and playful experience. This would make virtually anyone a potential user and would also allow us to test our installation 'in the wild', with 'real' people outside of any controlled test setting. We went through a process of scouting possible locations and mapping out potential advantages and disadvantages associated with them. We ended on concluding that an ideal exhibition space would be Norsk Teknisk Museum (Norwegian Museum of Science and Technology) ((3) Figure 4.1), as this is a space where interacting with the exhibition is a natural part of the behaviour. In a context like this we imagined the time spent by visitors experiencing the installation to be relatively short, maybe two to five minutes, as they would be continuously moving between parts of the exhibition.

4.2 Technological exploration

Neither of us had any previous experience working with the Kinect sensor. Although we had certain ideas of what could be done with the device, we had little insight into the particulars of how to design and program for it. It was therefore important for us to get our hands dirty as soon as possible. After buying a Kinect each, the first steps were to install the necessary drivers, software, and libraries in order to be able to communicate with the Kinects.

4.2.1 What is a Kinect and how does it work?

What is a Kinect?

The Microsoft Kinect sensor is an exertion interface that was originally developed as an optional accessory to the XBox 360 game console for controlling games and interactive experiences through body motion, gestures and audio. As of spring 2013, there are two different versions of the Kinect on the market: Kinect for XBox and Kinect for Windows, which also comes with a Software Development Kit (SDK). This SDK allow developers to create programs for the Windows platform using the sensor.

Soon after its release the Kinect was 'hacked', and several independent open source drivers and SDKs were released during 2010. The most prominent of these is the OpenNI framework, released by the Open Natural Interaction (OpenNI) organisation (http://www.openni.org/about/), in which the company PrimeSense (http://www.primesense.com/) is a member. PrimeSense is an Israeli company that originally developed the sensor for Microsoft.

How does a Kinect sensor work?

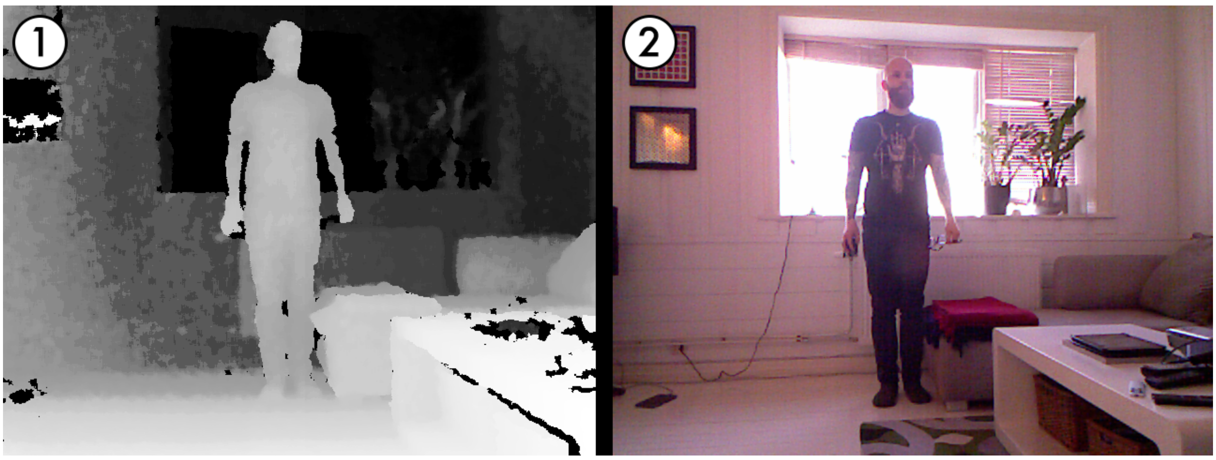

Figure 4.2: Output from the two visual sensors on the Kinect. (1) Depth camera. (2) RGB camera.

The Kinect has two visual sensors: A normal RGB (Red Green Blue) camera and depth sensor, or structured light 3D scanner (Figure 4.2). The depth sensor consists of a infrared (IR) transmitter and receiver. The sensor works by projecting IR light in a pattern of dots into the space in front of it. The pattern is deformed by the surfaces it hits, and the deformed pattern is reflected back to the IR receiver. Depth is then calculated by measuring the deformation of the received pattern in comparison to the transmitted reference pattern [45]. An example of a visualisation of this pattern can be seen in section 4.3.1. In addition, the Kinect also has four microphones, which makes it possible to create applications that react to verbal input as well as motion [46], although this functionality was only available through using the official SDK from Microsoft, at the time of our prototypes' development.

A drawback of this technology is its sensitivity to sunlight, as it uses an IR projector. This also makes it quite sensitive to reflective surfaces like windows, white walls and mirrors. This is an important consideration when choosing context and placement for an installation like this [47].

What a Kinect sensor see

This sensor has a cone shape field of view (FOV) with an horizontal angle of 57.5° and a vertical angle of 43.5°. The range of the IR projector limits the length of the FOV, so Microsoft specifies an approximate depth range of 0.8 meters to 4 meters, with a safe zone of 1.2 meters to 3.5 meters. Users can still be tracked further away than 4 meters, but tracking data gets considerably noisier outside this limit and is considered unreliable [46].

Field of view

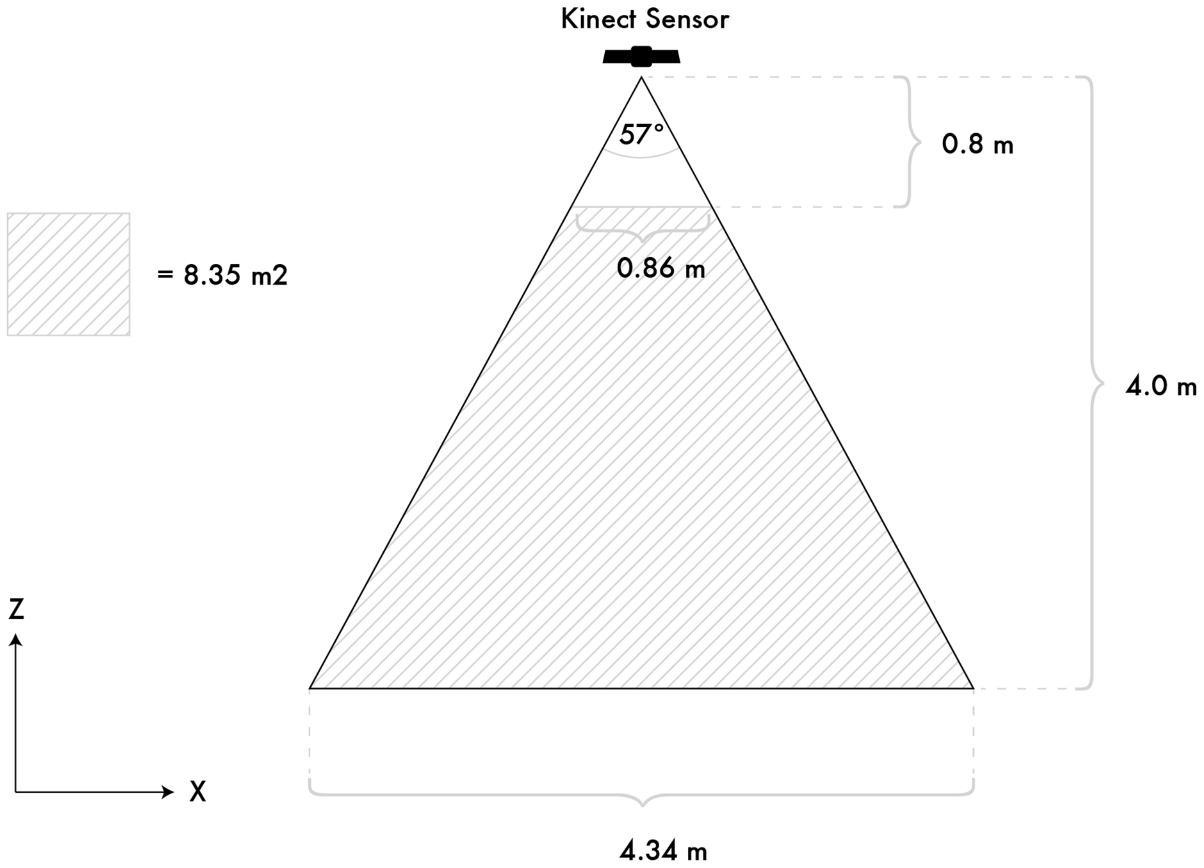

Figure 4.3: A top down view of the approximate area a Kinect sensor can cover along the X and Z-axes

The area covered by the Kinect sensor is in the shape of cone, which makes a triangle along the X and Z-axes (width and depth) of the room when facing the sensor. We decided on dividing this triangular area into a grid system of equally sized zones, where a user would trigger functionality in the system based on which zone their position corresponded to. The reasoning for, and a more in-depth description of this design is covered in section 4.6.1. To design this zone system we needed further measurements to calculate distribution of the zones than those provided by Microsoft. These can be seen in figure 4.3.

4.2.2 Division of system and tasks

One of us is a graphic designer and computer engineer, the other a sound engineer. In order to take advantage of our existing skill sets and knowledge, we agreed to divide the tasks of designing and developing the system along the same lines: One would design the visual part of the system, the other the audible part. This way we could explore the technologies that best fit our needs.

4.2.3 Drivers

The choice of drivers was in reality a choice of operating system. The Kinect SDK only runs on Windows, while OpenNI runs on Windows, Linux, and OS X. As we both own Apple laptops running OS X, and were more comfortable with this environment, we decided to use OpenNI. It allowed us to get up and running quickly with the hardware we had at hand.

4.2.4 Processing and Java combination

After successfully installing the drivers, the quickest way to get something up and running was to use Processing or p5 for short. Processing is a free, open source and cross-platform programming language, and can in short, descriptive terms be summed up as follows:

> *Processing is a programming language, development environment, and online community that since 2001 has promoted software literacy within the visual arts. Initially created to serve as a software sketchbook and to teach fundamentals of computer programming within a visual context, Processing quickly developed into a tool for creating finished professional work as well.* (http://processing.org/about/)

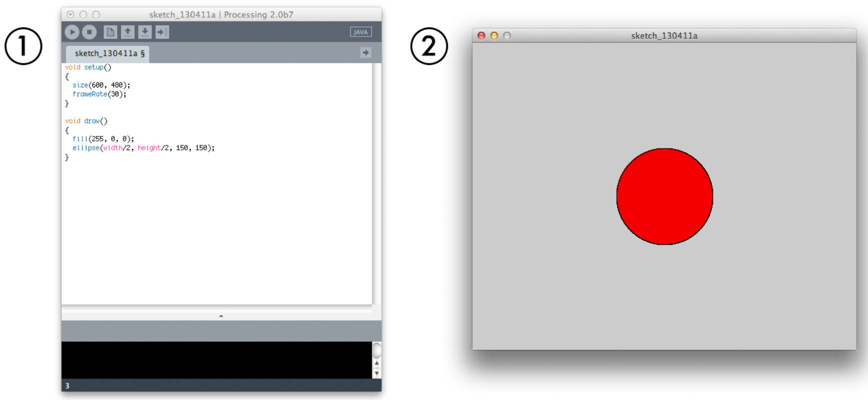

Figure 4.4: A simple Processing program that draws a red circle (1) The source code in the Processing development environment. (2) The application window of the running program.

Benefits of Processing The syntax of the Processing language is relatively easy to understand and is in essence a simplified form of Java. In fact, behind the scenes it is actually Java and runs in the Java Virtual Machine (Java VM) when it's compiled. It comes with a programming framework that includes an extensive set of tools that encapsulates and simplifies complex tasks related to audio, video and image processing, graphics and animation. Additionally, the processing community has created a myriad of free open source libraries and tutorials for solving tasks of this nature, that can be found online. This makes Processing very attractive as a relatively fast and easy way to create rich visual expressions, when the alternative often can be diving down in complex and time consuming activities like OpenGL programming. In later years, several ports of the language and programming framework has been created for other platforms, for example processing.js for JavaScript, as well as ports for iOS (iProcessing), android (Mobile Processing) and Wiring (used for arduino).

As previously mentioned, Processing comes with its own editor and programming environment (Figure 4.4), where aspiring developers can write processing code in its simplified form and run programs with the click of a button. But since Processing is so tightly connected to Java, the processing core code can also be used in normal Java applications or applets as a library in your preferable Java editor, like Eclipse or IntelliJ. This was the path we chose, since we already had quite extensive experience with developing in Java and preferred to write full Java code instead of the simplified form used in Processing. This enabled us to combine both third party libraries written specifically for Java, libraries written for Processing, as well as taking advantage of the full power of the Java language.

A simple Processing program In its simplest form, a Processing program consists of two methods ((1) figure 4.4): A *setup*-method and a *draw*-method and do more or less what their names suggest. The setup-method runs once when the program start, and in this method is where the developer creates and initialises the variables and tools to be used in the program, for example the size of the program window. The draw-method contains instructions to draw what appears on screen, but also computes everything that decides what actually is drawn, based on user interaction or other parameters. It runs over and over again, several times every second, depending on which value is specified in frameRate in the setup-method. This method is basically what is known in game programming as a *game loop* (http://entropyinteractive.com/2011/02/game-engine-design-the-game-loop/), and is *the* central mechanism for running a game or animation. Our use of the game loop is described in further detail in section 4.6.2.

Simple OpenNI SimpleOpenNI is a OpenNI wrapper library for Processing that provides easy access to the functionality of the OpenNI driver. It includes a number of small, ready to run sample-programs, or sketches as they are called in Processing. These provided a good way for us to get started exploring how to code for the Kinect. We also found a very instructive book called *Making Things See* [48], that provided step-by-step tutorials and code-examples for using Processing with the Kinect.

Other resources Two of the most useful resources we came across was the book *Nature of Code* [49] written by Daniel Shiffman and the library *toxiclibs* [50], developed by Karsten Schmidt. Toxiclibs is a free open source Java and Processing library with a collection of tools for computational design tasks, including tools for image processing, audio processing, colour manipulation and generation, trigonometry math and physics engines for 2D and 3D space, among others. Nature of Code is available both as a printed version, as an e-book, and as a free online version at http://natureofcode.com/, with working examples running in the page through processing.js. According to its website, the book is described as focusing *"...on the programming strategies and techniques behind computer simulations of natural systems using Processing"* [49]. Both these resources became invaluable in the design and development of the final visual prototype.

Drawbacks of Processing However, Processing has its limitations, one of which is the capabilities for audio programming. Although it has libraries for audio programming, these are not optimal for our purpose. It was therefore necessary to explore other options building the sound system.

Another limitation lies in its simplicity. Even though it is reasonably easy to quickly create basic 2D and 3D graphics, creating complex graphics like blurs, blend modes, bitmap textures, combinations of 2D and 3D graphics, etc. can be quite cumbersome and performance limiting, as one might be required to dive into more low level programming. This limitation is especially prominent when creating an installation like ours, which demands close to real-time responsivity.

At last there are the limitations of performance. When doing heavy tasks like rendering complex graphics, calculating physics, and doing collision detection for large particle systems, Processing runs quite a lot slower than code written for a specific operating system in C++. This is due to the fact that compiled Processing code is Java running in the Java VM, and the code involves several layers of abstraction.

Why Processing? Despite these drawbacks, we ended up choosing Processing in combination with Java as our tool for creating the visual system. The main reason behind this decision was its simplicity. It has a low bar of entry for new users and since we had very limited time available for learning a new language and do the programming required, as well as our prior knowledge of Java, it seemed the only feasible option.

4.2.5 openFrameworks and Cinder

As Processing, openFrameworks (oF) and Cinder are free, open source libraries or frameworks for 'creative coding', and are also designed especially for audio, video, graphics, image processing and alike. The main difference between Processing on one side and oF or Cinder on the other, is that oF and Cinder are created with, and is programmed in the C++ language.

Both oF and Cinder has several advantages over Processing in terms of performance, built in possibilities for complex graphics and, particularly concerning oF, a larger availability of advanced third party libraries developed by the oF community.

We ended up not choosing any of these two, mainly because of time constraints in terms of limited development time and the quite steep learning curve necessary to master C++. We had some prior experience with C++, but not nearly as much as with Java. Since C++ is a significantly more low level programming language than Java, which demands considerably more of the programmer, our assessment was that we could not risk spending the time required to get familiar with a new programming language as well as a new framework of tools.

4.2.6 Max/MSP/Jitter

After doing some research we discovered an article describing the development of an *"accessible Max/MSP/Jitter interface to the Kinect's depth map bundled with a user-tracking library"* [51, p.1]. This *Kinect-Via-OSCeleton*-interface provides communication with the OpenNI driver through a bundle of middleware, thus making it possible to access tracking-data from the Kinect through the Max/MSP/Jitter programming environment (hereafter referred to as 'Max').

Max is a visual, fluid, and immediate programming environment for creating music, sound, video, and interactive media applications [52]. One of the strengths of this environment is the ability to not only visually monitor the code during runtime, but actually perform changes to the code while it is running, and to see the effects of the changes 'live'. This provides a powerful way of debugging the code and a way of learning-by-doing that is not available in more conventional, text-based programming languages. It is also a relatively complete environment with all the necessary tools, eliminating the need to install a variety of supplemental libraries to provide desired functionality.

Max provides advanced tools for digital audio programming. However, within the time limits of our project it was difficult to justify spending months on developing special purpose sound-synthesis algorithms or sample playback system, when our focus was on designing pleasurable user experiences.

But Max also provides MIDI-functionality (Section 4.2.8) that allows for communicating with more conventional audio production software like Logic Studio or Ableton Live. This enabled us to use the powerful audio-synthesis and audio-processing features of Logic Studio (Section 4.2.7) to set up the sounds we wanted to use in the installation, and control the playback of those sounds through MIDI-messages sent from Max. A program in Max is called a 'patch', and our Max patch would receive raw, continuously changing tracking data from the Kinect. It would process that data according to a logic designed to capture certain movements and gestures from the users, and then send MIDI messages to Logic Studio to trigger and modify pre-selected sounds.

By using Logic instead of Max to generate sounds we severely reduced the time spent on sound-design, and could focus more of our attention on exploring how to design the interaction. It is important to underline that this solution would be unbearable in a commercial project where the developed code would be packaged and sold as a product, as it would be dependent on Logic Studio, which costs more than $500 in Norway. But as we already owned a Logic Studio licence, it was a good opportunity for us to severely reduce the development time.

4.2.7 Logic Studio

As already mentioned, Logic Studio is a professional audio production software. It is commonly used by musicians, sound designers, and other audio professionals and amateurs. It provides advanced digital audio processing capabilities, and includes a vast array of sounds, software instruments, effects, and tools for complex sound synthesis. Logic Studio can be controlled by a multitude of different external hardware-controllers, such as keyboards and samplers, through its use of the industry standard MIDI protocol. Logic Studio provides an easy and powerful way of mapping any incoming MIDI signal to a specific parameter, thereby enabling artists and designers to customise their setups to fit their specific needs. This functionality enabled us to set up our Max patch to send MIDI note-events and control-messages to Logic based on the tracking-data received from the Kinect, thereby effectively giving the user the control over certain sounds and parameters in Logic Studio.

4.2.8 MIDI

MIDI (Musical Instrument Digital Interface) defines a standard way of communicating between different electronic music hardware and software [53]. It communicates information about note events (on/off), pitch, duration, and velocity of different notes, as well as a range of control messages for adjusting different parameters and synchronising devices.

4.2.9 Installation makeup: One or two systems

As we developed an understanding of the technologies needed to build our installation, we realised that our decision to develop visuals and audio separately also forced us into making another decision: Should the whole installation run from a single computer, or should we use separate computers for the visuals and audio parts of the system?

One computer, one Kinect Running everything on a single computer initially seemed like the tidiest way to go as both audio and visuals would respond to the same tracking data coming from a single Kinect. However, upon further investigation, we realised that the OpenNI drivers did not allow two programs to access the tracking data simultaneously. The only way around this problem was to use one program to access the tracking data, and then use UDP (User Datagram Protocol) and OSC (Open Sound Control) to pass the data onto the second program (Figure 4.5). UDP is part of the internet protocol suite, and allows applications to send messages between each other over a network [54]. OSC *"is a content format for messaging among computers, sound synthesizers, and other multimedia devices that are optimised for modern* *networking technology."* [55] We did some simple tests sending messages back and forth from Processing and Max using UDP and OSC.

Although we were able to communicate between the two programs, it quickly dawned on us that this would severely complicate the design process, and introduce a range of potential communication errors between the systems. It would also be much harder to divide the workload between us and we would have to share much of the same codebase. This would demand a much tighter cooperation on a micro level and we would end up spending a lot of time on integration of audio and visual parts of the code, instead of focusing on concept work and exciting functionality. Furthermore, the tools and programming languages best suited for audio differs fundamentally from the ones suited for complex graphics. Last, but not least, running both audio and visuals on the same computer would demand considerably more powerful hardware, with plenty of processing power.

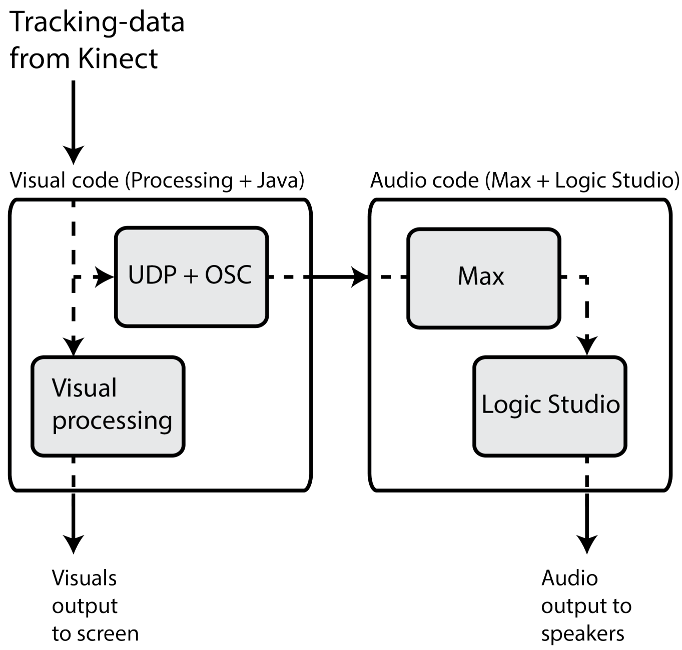

Figure 4.5: Entire installation running on a single computer: One program (visual) accesses the tracking-data, and then uses UDP and OSC to pass the data onto the second program (audio).

Two computers, two Kinects On the other hand, by running audio and visuals from separate computers, we would in effect be building two separate installations. Each installation would use a dedicated computer connected to a Kinect, and would output its feedback (audio or visuals) independent of the other. This option left us both free to explore more openly, and to build our separate code according to our specific needs. The challenge for us would be to ensure that the two installations would play 'in harmony' and be perceived by the user as one single system.

This option also introduced other problems and potential errors. First of all, by using separate Kinects for the two systems it would be crucial that the two were properly calibrated and aligned, ensuring that they respond in unison to user's movements. We felt that by continually testing and aligning our systems it would be possible to minimise this problem.

Interference But a more serious issue was the trouble of interference. Using two Kinects in the same room introduces interference between the IR signals of the two devices. This leads to a degradation of both signals, thus making the tracking-data less reliable and makes the tracked joint positions 'jump' at irregular intervals. As this was still quite early in the exploration process it was difficult for us to determine how serious this problem would become, but after doing some research we found a couple of articles [45, 56] describing a low-tech remedy to the problem: By introducing a small amount of movement, or vibration, to one of the Kinects, the interference can be significantly reduced. This vibration can be achieved by mounting a small electrical motor with variable speed on one of the Kinects. With a small weight mounted slightly off-center on the propeller shaft of the motor, engaging the motor will introduce small vibrations to the Kinect. The speed of the motor is used to tune the vibrations (approximately) to the framerate of the Kinect, ensuring maximum effect of the vibrations. We used a processor fan from a PC as electrical motor with a piece of tape as an offset weight on one of the rotor blades, and had some help assembling an ad-hoc voltage-regulator acting as a speed control (Figure 4.7). By strapping the fan to one Kinect, and then running both Kinects at the same time we could switch the motor on and off, and watch the degradation come and go in the depth-images of both Kinects (Figure 4.6).

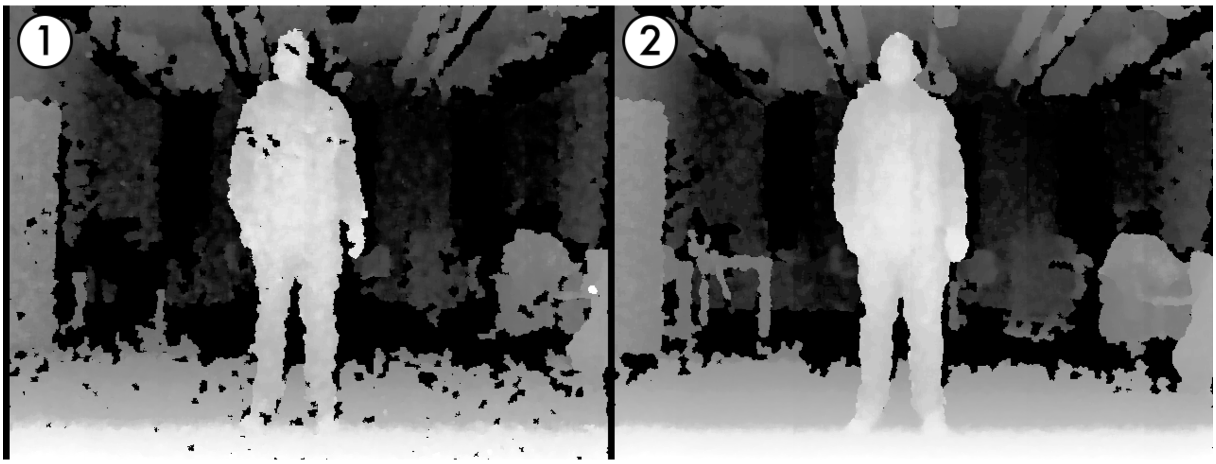

Figure 4.6: (1) Interference from second Kinect evident by black spots. (2) Interference reduced by vibrating *one* Kinect.

Two computers, one Kinect This solution was also considered as a serious contender for a while. It would have involved a combination of the two other solutions; separating the codes of the two systems on two separate computers, but using only

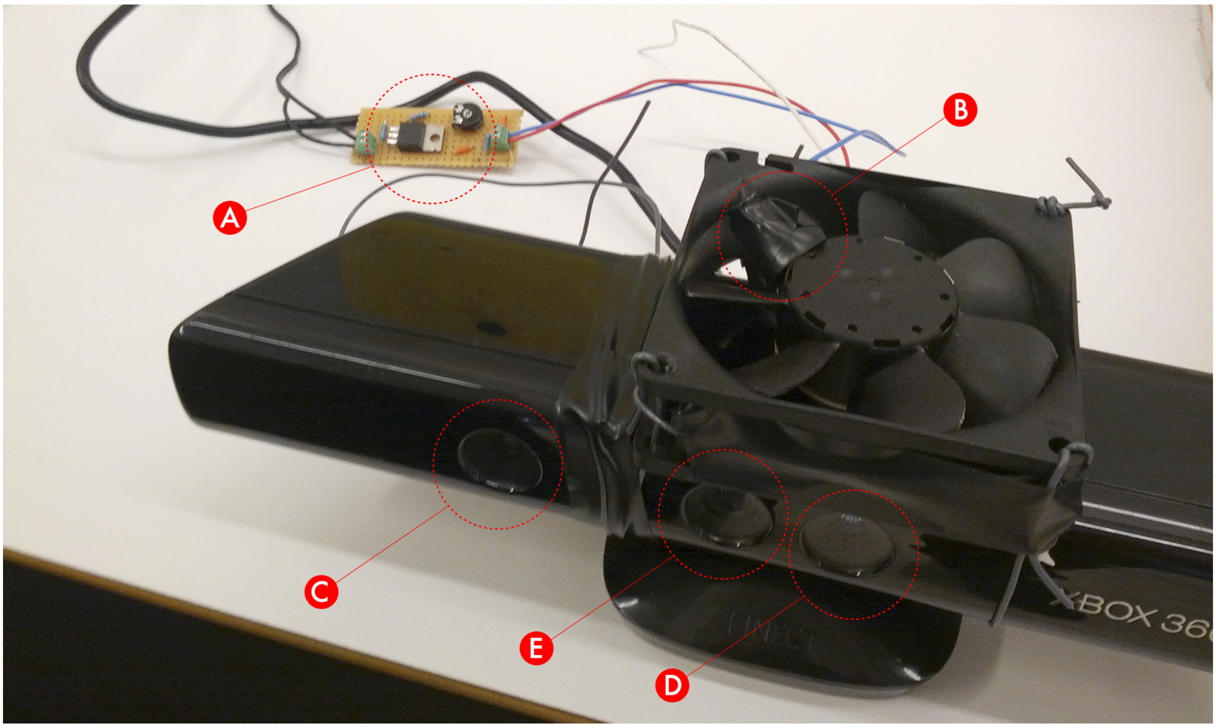

Figure 4.7: Kinect mounted with interference reduction device. (A) Motor speed controller (B) Processor fan with weight fastened to blade (C) IR projector (D) IR camera (E) RGB camera

one Kinect. One of the computers would act as a 'master', accessing the Kinect and passing the raw tracking data onto the other 'slave' computer using UDP and OSC.

This would have allowed us to develop our different systems relatively independently and put less demands on the processing power of the computers. However, the deal-breaking drawback of this solution is simply the potential latency issues involved by sending large amounts of data, up to 30 times every second, between the two computers. This would potentially result in lack of responsiveness for the participants of the installation. The solution would also involve a lot of the same communication and integration issues described in the 'One computer, one Kinect'-option.

Concluding on setup Taking into account our quite different backgrounds and expertise, the pros and cons of different hardware and software constellations available and after running some further tests, we decided that the benefits of building two separate systems with one Kinect sensor each, far outweighed the limitations. We were free to creatively explore functionality independent of each other and avoided spending time on technical communication and integration issues, while still having a strong conceptual connection between the two systems. This allowed us to spend more time and resources on our primary area of interest; designing enjoyable user experiences. The choice of creating two separated systems for audio and visuals were also partly inspired and definitely supported by the experiences outlined in *V Motion Project – Part I: The Instrument* [44].

4.3 Exploration of functionality through prototypes

A string of small prototypes As outlined above, a major part of the early design process was establishing our possibilities within the limitations that existed and actually learning how to use a wide range of tools and combining them. To achieve this knowledge we created a range of small high fidelity prototypes in quick succession. The following section will quickly run through most of these. Functionality from several of these prototypes were included in a modified state in the final prototype.

4.3.1 Visual prototypes

The earliest of the visual experiments, such as 'depth image', 'RGB and depth image finger drawing', 'stickman skeleton' and 'depth point cloud and button in space ' were based on examples and exercises from the book *Making Things See: 3D vision with Kinect, Processing, Arduino, and MakerBot* by Greg Borenstein [48].

Depth image

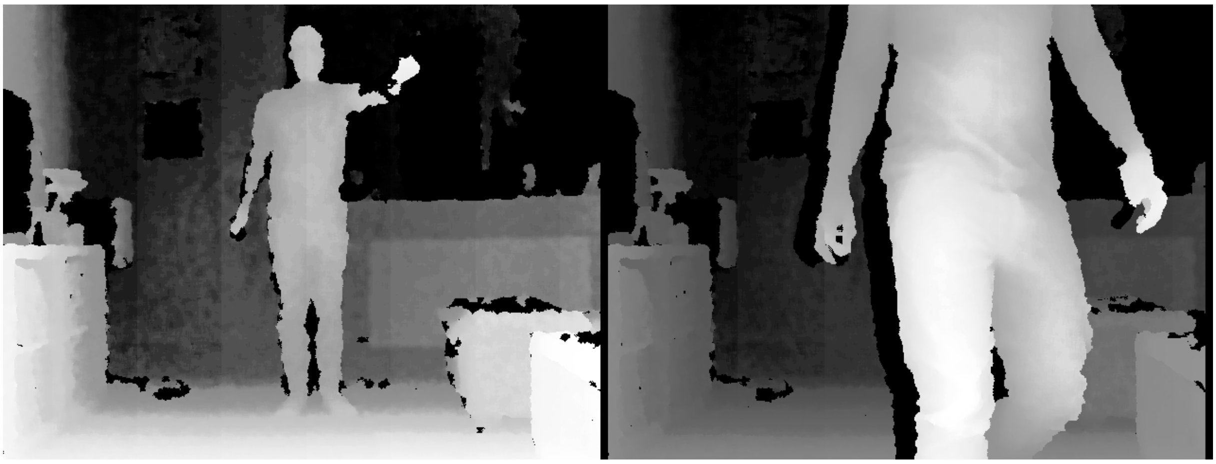

Figure 4.8: Two depth images from the 3D sensor

This was the very first visual prototype made, which basically consisted of setting up the programming environment and ensuring the Kinect works correctly by displaying the depth image returned from the driver. The depth image is a monochrome image where the hue of each pixel corresponds to its depth in the space observed. Pixels closer to the sensor are light and pixels further away are darker (Figure 4.8).

RGB and depth image finger drawing

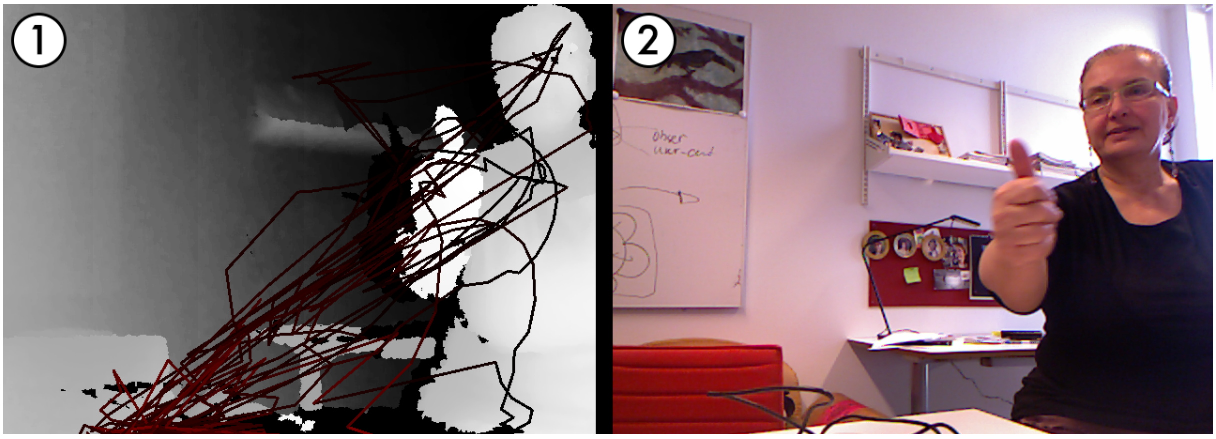

Figure 4.9: Our thesis supervisor testing 'RGB and depth image finger drawing' prototype.

This prototype consists of displaying an image from each of the Kinect's two sensors (Figure 4.9), displaying the depth sensor image (1) and the RGB camera (2). The functionality of this prototype enables a user to draw a line on top of the depth camera image with the point closest in the depth data returned by the sensor. The line drawn varies in colour according to the distance from the sensor to the closest point.

This was created to learn how to handle the raw depth data coming from the OpenNI framework. This data is, simply put, an array whose length corresponds to the total pixels of the depth image and it is ordered according to these pixels in order from the top left. Each of the array positions holds a value. The value is the distance in millimeters from the sensor to the corresponding pixel in the depth image. A value of zero signifies either a value out of the range of the sensor, an area in shadow or a reflective surface, which means in essence an invalid reading and will turn out black on the depth image.

Point cloud and button in space

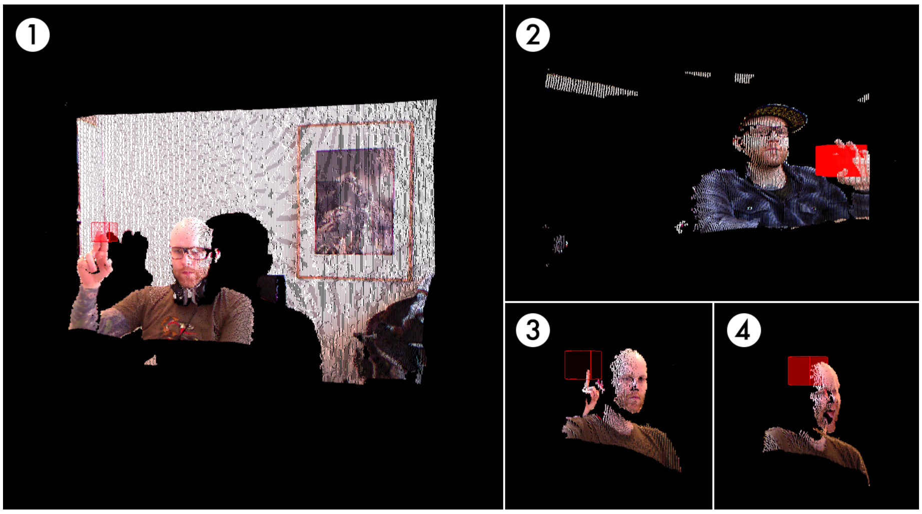

Figure 4.10: (1) Rotated point cloud with box as a 3D button placed in 3D space. (2) Fully active 3D button. (3) Inactive 3D button. (4) Partially pressed 3D button.

The aim of this prototype was to try combining data from the depth sensor and the RGB camera to create a visualisation of what the Kinect actually sees in 3D space, while also testing out very simplistic interaction methods.

Moving the mouse could rotate the continuously displayed point cloud. The point cloud seen in (1) figure 4.10, is rotated about 30° from the sensor's angle of view and shows that the Kinect sensor only sees in '2.5D' as only surfaces facing the Kinect are visible. To explain 2.5D, one can think of a Kinect's depth sensor as a flashlight shone upon object in a pitch black room. Only the surfaces facing the flashlight would be visible, all other objects would still be in darkness. To get a complete 3D scan or point cloud one could use multiple Kinect sensors placed to cover all 360° of the scene in question, as done by Daniel Franke and Cedric Kiefer in their *unnamed soundsculpture* [57]. This was an important experience for the design process going forward, enabling us to take this into consideration in the final prototype by adding the 'too close' zone (Section 4.5.2). The aim of the 'too close' zone is to encourage users of the installation to move away from the sensor and lessen the chance of other users being caught in the shadow of the closest person.

We also added a 3D box or 'button' as an interactive element to test how one could interact with an object statically placed in the virtual space. The button was activated by the system checking if points of the point cloud were inside the 3D space of the box. The more points registered inside the buttons boundaries, the less transparent it gets. In (2) figure 4.10, the button is fully active and opaque, meaning the maximum level of points has been reached. In image (1) and (4) it is partially transparent, whereas in (3), no points are registered inside the button's boundaries. Although this specific concept was not transferred into the final prototype, this type of interaction could be quite useful to let users control a range-based parameter like sound volume.

A potential problem we experienced with virtual buttons as a three dimensional interface elements, is that they can be quite hard to hit. They require you to look at the screen instead of the world around you, even though its position is actually in real world space. This experience can be compared to the process of picking up an object only aided visually by looking in a mirror, in which you have no eye-hand coordination to help you. A partial solution to this problem could be to aid the users with on-screen representation of themselves, or at least their hands, in the way a mouse-pointer does. This way, the problem would be solved for 2D interfaces on the X and Y axes, but the issue of depth would still be present for 3D interfaces. This is definitely a challenge when mirroring or mimicking the real, three-dimensional world on a two-dimensional screen.

Stickman skeleton

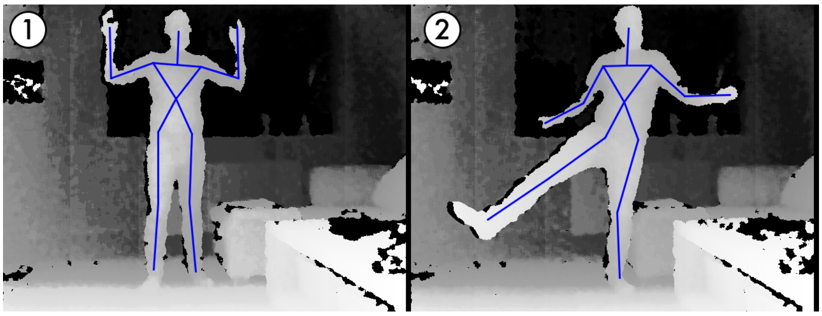

Figure 4.11: (1) Initialisation pose for the Kinect driver. (2) Skeleton superimposed on user.

The skeleton prototype was a quick implementation of an example in Borenstein's book [48]. In all its simplicity it enables full skeleton tracking of a human being. It finds all the joints trackable by the OpenNI driver and draws the limbs joining them on top of a depth image. When the driver is set to use skeleton tracking, it returns a list of users with points corresponding to the users' joint-positions for every update cycle. These positions are a lot more convenient to work with than the raw depth data mentioned earlier, as it is no longer necessary to parse and interpret the complete data set, since OpenNI does this job for you. This is the main way of tracking users in the final prototype.

Red line drawing

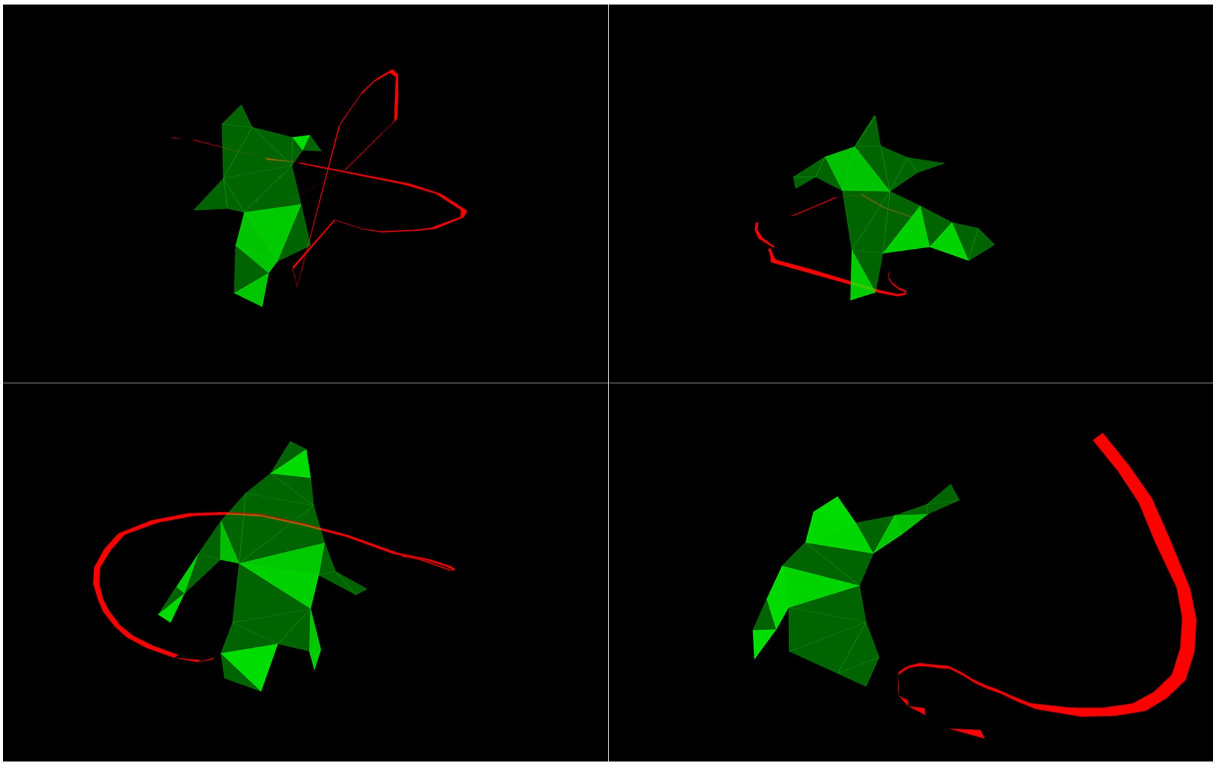

Figure 4.12: Four screenshots of the red line drawing prototype with an on screen user representation

The line drawing prototype was the first major prototype remotely similar in functionality to the final installation. Parts of the code and concept of this prototype later became the basis of the 'Bass bar' mode of the final installation.

Its functionality was limited to single users only, but this participant could see a representation of herself on screen while using her right hand to draw a red line of limited length in three-dimensional space (Figure 4.12). A software camera was also used to change the point of view to focus on the current position of the right hand at all time.

By using the OpenCV library for Java to analyse the RGB images of the Kinect camera we succeeded in creating a simplified on-screen user representation (Figure 4.12). When someone entered the installation's field of view, but before the OpenNI driver had managed to calibrate and start tracking the person, the user representation was coloured red, changing to green when the calibration was successful. The technical solution and visual style of the user representation for this prototype was strongly inspired by the making-of blog-posts from the *V Motion Project* [44, 58].

We gained a few important experiences with this prototype, the most prominent being that the constantly shifting viewpoint of the camera made it hard to control the drawing and the interaction quite confusing. This was especially noticeable, as the line drawn was not conforming to the position of the hand of the user-representation. The shifting viewpoint locked to a point also made it impossible to enable drawing with other limbs, not mentioning the inability to enable more users to take part. A secondary experience on the purely technical side was that the image analysis done by the OpenCV library used a good portion of the CPU resources available.

Paint with 3D objects

Figure 4.13: Four screenshots of the red line drawing prototype with an on screen user representation.

'Paint with 3D objects' (Figure 4.13) was basically an iteration of 'Red line drawing' (Figure 4.12), keeping the basic functionality and user representation on screen. This prototype enabled using both hands to draw, but instead of drawing a line, the position of the hands acted as points for spawning 3D-objects at short intervals. The right hand emitted randomly coloured spheres, while the left hand created cubes. The cubes and spheres had a crudely implemented particle physics behaviour, which made them float to the top or bottom of the screen before being removed from the system.

We attempted to create a richer visual environment on-screen by adding several software lighting sources to shine upon the objects created by the participant, and by adding a patterned bitmap background. The prototype ended up having really poor performance, even with only one participant, so the learning point from this experience was mostly technical, though still important and valid in other areas: It is very easy to reach performance limits in visual programming, so 'Keep it simple, stupid'.

Another important point of wisdom gained was that thinking in 3D space and then programming a faux 3D visual representation becomes exponentially harder than keeping to 2D space. This applies especially to mapping the participant's full body interaction in physical 3D space to a sensible and intuitive visual response in imitated 3D space on a two dimensional screen surface, just as in the 'Point cloud and button in 3D space' prototype (Figure 4.3.1).

4.3.2 Audio prototypes

Drunk drawing

This prototype was built during the initial exploration of Max while getting to grips with how the code worked and exploring different tutorial patches. It was a modification of a tutorial demonstrating how to design a patch that enables the user to draw, or spray, a cluster of randomly coloured dots onto a canvas by moving the mouse-cursor over the canvas. Our modification consisted of mapping tracking-data from the Kinect to control the cursor, allowing the user to control where the dots were painted by moving her right hand. We also mapped the height (Y-axis) of the left hand to the rate of the sprayed dots, making it possible to regulate the flow of colours.

Trigger tests

The first prototypes for the audio system were focused on converting tracking-data from the Kinect into MIDI note-messages, and using them to trigger sounds in Logic Studio.

User distance from Kinect We set the Z-values of the user's torso to determine which notes were played, where Z means the distance from Kinect. By walking towards and away from the Kinect, the user would cross certain boundaries represented by Z-values, and thus trigger a given note. We experimented with a range of sounds, from a simple piano, to speech, to samples from nature (e.g. thunder, rain, animal sounds), and quickly learned that the choice of sounds had a big impact on the experience. Behaviour induced: Running back and forth, rocking back and forth between two sounds, slow 'searching' walk, jumping.

Hand to neck distance By continually measuring the distance between the hand and the neck it was possible to set a threshold distance to use as a trigger; when the distance was greater than the threshold, a MIDI-note was triggered. This meant that the sounds would be triggered by the user extending their arm out in front of them. This way of triggering opened up a whole range of different gestures that could be used to trigger sounds (swipe, punch, wave, one arm/both arms, kicking, jumping, etc.). User movement was greatly affected by the sonic qualities of the given sound. It was also to a certain extent possible to time triggering of sounds in order to play sounds rhythmically.

Hip-height as threshold By setting a height-threshold in the height of the user's hip, sounds could be triggered by lowering the hands to hip-height or below. Behaviour induced: Piano-like gestures as if the user was standing in front of an oversized piano playing one key at a time with their hands.

One-shot trigger Logic Audio provides several different ways of triggering notes or sounds. One-shot triggering implies that the triggered sound will play its full length once it has been triggered. This is useful in situations where you want to trigger other sounds while the previous is still playing, and can be compared to holding the sustain pedal on a piano continually depressed while playing.

Trigger and hold Trigger and hold, on the other hand, works like a piano when the sustain pedal is not in use: A short tap on a key will produce a short note, while holding a key depressed sustains the note until the key is released or until the note dies.

Indiana Jones whip

By measuring the change in hand-position over time it is possible to calculate the speed of the hand. We set up a Max patch that continually monitored the speed of the hand, and used the hand-to-neck threshold distance as a trigger (Section 4.3.2). The speed value at the moment of triggering was used to determine the pitch of the sound being played. We recorded the sound of a whip and set it up to be triggered in Logic Studio. The effect for the user was that by doing a Indiana Jones-like whipping-motion (the hand is pulled back then forward in a sweeping motion, into a quick punch forward with a snap back at the end), the sound would be triggered as the hand is at the end of its forward trajectory, just before it is snapped back, giving the user a visceral and direct sensation of wielding an invisible whip.

By using the speed of the hand to determine the pitch, a slow movement would produce a low-pitched and slow whip-sound, a medium speed would produce a 'normal' sound, while a fast punch would produce a short and crisp whip. However, getting a reliable and consistent speed calculation proved challenging as it required monitoring speed along all three axes (X,Y,Z) and determining in which direction the motion was the greatest. This resulted in a somewhat arbitrary pitch being played, but the responsiveness of the triggering still gave the user a real sense of actually using a whip. Behaviour induced: Whipping motions, swipes, hits, quite sudden and forceful/violent movements.

Body Measurements

Children and adults have differing arm-lengths and reach. Using the hand-to-neck distance to trigger sounds meant that the threshold distance would need to work for both children and adults. Setting a static distance might prove too far away for children, or too close for adults. To solve this problem, we set up some code that measured the length of individual body parts of the users when they were discovered by the system, and compared these lengths to a template based on our own body measurements. This allowed the system to automatically determine the best threshold-distance (hand-to-neck) for triggering sounds. This worked quite well, but was somewhat vulnerable to inaccurate initial user measurements, sometimes leading to quite erratic system behaviour and confusion for the user.

Air piano

v.1 This prototype was developed into two versions. The first utilised the 'hip-height as threshold' in combination with the 'trigger-and-hold' trigger method (Section 4.3.2). By tracking the position of the hands along the X-axis (horizontal, left-right) it was possible to divide the whole range from extreme left to extreme right into a row of eight equally sized zones. Each of these zones behaved like the key of a piano. By extending their hands down in front of them, users could trigger notes corresponding to the zones their hands were in. If a user was to move from left to right while continually tapping his hand down below the trigger threshold, the played notes would correspond to a C-major scale, representing the white keys of a piano. Assigning any melodic instrument to this setup allowed the user to play simple melodies within a one-octave range.

v.2 The second version of the air piano used the 'hand-to-neck distance' trigger method. The zones along the X-axis (corresponding to keys on the air piano) were the same as in the first version, but the trigger gesture would be to extend the hands out in front of the user (using the Z-axis). By allowing the triggering to be independent of the height (Y-axis) of the hands, the Y-axis could be employed to control the volume of the notes played. By raising their hands, the played note would increase in volume, and lowering them would have the opposite effect. This allowed the user to not only play melodies with a certain control over rhythm, but to independently adjust the volume of every note, and proved to be a quite expressive way of controlling an instrument. This prototype also employed the 'trigger and hold'-method (Section 4.3.2) for triggering sounds in Logic Studio, allowing the user to control the duration of the triggered sounds by keeping their arm extended.

Swordfight (Audio)

This prototype used the same code as the Indiana Jones whip prototype (Section 4.3.2), but instead of using the whip sound, we designed a range of different swordfight sounds (sword hits, swooshes, swipes, and 'zings'). Also, instead of using one sound and varying the pitch according to the speed of the hand, the speed-value determined which of twelve different swordfight-sounds were used. This provided randomness in the choice of sound, playing different sounds every time the hand is brought forward, and giving a strong impression of actually engaging in a swordfight with a virtual and invisible opponent. Behaviour induced: Swipes, jabs, back-and-forth, up-and-down, chopping, fencing-stance (one foot forward, weight on rear leg, knees slightly bent), wild waving of both arms, quite forceful and violent motions, but also more calm and searching motions, kicking.

Music playback

After discovering how to set up our installation to automatically detect users, we decided to explore the use of music as a backdrop to the sounds produced by the users. We set up some code that basically worked as a music player, continually playing through a list of songs. When the installation was idle, meaning there were no users in its field of view, the volume of the music was turned off. As soon as a user was identified, the music would fade in at whatever point it was at in its loop. Shortly after the last user had left its field of view, the installation would fade the music out again. In this way the installation had a non-intrusive way to audibly acknowledge the presence of users. We also experimented with various ways of manipulating the speed of the music through user movement.

4.3.3 First public prototype test - Gemini UX lab opening

The Institute of Informatics opened the new UX Gemini Centre September 19th 2012, and we were invited to display an early prototype of our installation at the opening. At this time we were working on the *Red line drawing* (visual) and *Swordfight* (audio) prototypes, and users had to do an initialisation-pose in order for the OpenNI driver to register them. Also, only one person at a time could be tracked by the systems.

The event provided the first opportunity for us to run our systems together and observe how people who had no knowledge of the system would react to it. However, the two prototypes were not designed to work together, and were therefore competing for the visitors' attention and confusing them about what to do. Some would try to control the red line on-screen, thereby inadvertently triggering sword-fighting sounds. This led some to start jabbing and waving more violently with their arms to simulate swordfighting.

There were approximately 40 guests at the event, and the lab-room was filled with a range of different student projects, making it relatively crowded and cramped. This confused our systems and sometimes made tracking users a little difficult. Nevertheless, our experimental prototypes seemed to draw a lot of attention and curiosity, and people were smiling and laughing while using it or watching others use it. There were also people who obviously thought the system could track several people. While another person was using it, they would try to do different gestures and movements to see if they got any response. We observed several people who seemed very curious to try the system, but were too shy to do it in front of a crowd of onlookers. Lastly, we realised that our prototypes needed a lot more work before they could be displayed in a public setting.

4.4 Exploration of design concepts

4.4.1 Inspiration

An important part of the first eight or nine months of project was the exploration of what other people or groups have achieved with creations or installations involving the Kinect sensor or related technologies and concepts. This included scouring the web for videos, tutorials, project description, tools, and examples. A great starting point to look for such resources is the website http://www.creativeapplications.net/, which is a digital art blog, focusing on *"...projects, tools and platforms relevant to the intersection of art, media and technology"*.

During this process, all valid inspirational references found were collected and posted on a publicly available tumblr-blog (http://robotcalmingnews.tumblr.com/) for sharing and further discussion within the project group. A comprehensive list of these sources of inspiration can be also found in Appendix F, but in this section we will present two selected projects we came across and how they influenced our own project.

V Motion Project

The 'V Motion project' was an interactive installation, music video or audiovisual instrument, depending on definition, created for promoting the New Zealand energy drink brand 'V'. The basic concept of the installation was creating music through motion.

The installation consisted of a person acting as the musician placed in front of Kinect sensors, a sound system and a big screen. The musician was represented on screen, similar to our 'Red line drawing'-prototype, (Section 4.3.1), placed in the middle of the screen and surrounded by a two dimensional graphical user interface that could be reached by extending arms and legs. The screen area around the GUI was reserved for visual effects, overlaid a range of landscapes synced to the music. When the musician 'played' the GUI, he controlled both sound and visualisation, as the sounds, music and the visual effects were synchronised [44, 58].

Impact on our project Discovering the V Motion project was quite a revelation in several ways. We both got excited and a bit disappointed when seeing this project. Excited by seeing that someone managed to design and realise something so cool and, at the same time, so similar to what we had envisioned to build. The disappointment was due to someone building it before us, but this also strengthened our belief that we were doing something right.

The main aspect that made the V Motion project so appealing to us were the concept of using full body motion to create interlinked sound and visuals, and that these together form a unified enjoyable user experience, both to participants and to onlookers. Other inspiring aspects were:

- The project was exhibited in a public context (downtown Auckland, New Zealand).
- Its incorporation of abstract and semi abstract visualisations matched with electronic music.
- Its apparent responsiveness to user actions.
- The utilisation of musical and visual modes
- The way of engaging functionality by extending arms to activate said function.

Additionally, the team behind the project made a series of blog posts [44, 58, 59], describing the development process and technology choices made, which were immensely helpful to overcome some of our own obstacles described in the technology section (4.2).

Firewall

Firewall was an interactive installation created by Aaron Sherwood and Mike Allison described as *"A stretched sheet of spandex acts as a membrane interface sensitive to depth that people can push into and create fire-like visuals as well as expressively play music."* [60]. By pushing into the membrane, the user triggered the playing of music and the speed and volume of the music was manipulated according to how deep the spandex was pressed.

Impact on our project Our installation was a much less complex one than the V Motion project, but herein lies also its captivating factor. In all its simplicity the Firewall encompasses, in our opinion, both calmness, beauty, and captivating qualities. Firewall was a major awakening for us when contemplating a concept for our installation, as we realised that we could still create an enjoyable user experience without creating something overly complex and intricate.

Other qualities we found desirable were for example the use of gestures and motion to manipulate an audiovisual experience, the perfect fusion of abstract visual expression with music, the users control over expression and its relative open-endedness of the experience. Apart from said spandex membrane coupled with Arduino, the technology used to build this installation is also very similar to what has been used for our prototype, using a Kinect, Processing and Max/MSP.

Inspiration from common movements and gestures

In the early stages of developing our concept, we wanted to explore how movements and gestures could be designed into our system. In designing intuitive and understandable gestures one needs to take into account the wide range of existing gestures people are familiar with, most of which carry significance in themselves.

Handwriting, calligraphy, graffiti, drawing Handwriting and calligraphy are highly controlled, precise, and flowing movements. We took inspiration from a popular drawing-app for iPad called Paper by FiftyThree. This app allows the user to draw freely using the touch-screen, and interpolates the traces the finger makes, eliminating small jitters and irregularities and creating a beautiful and smooth line. This gives the user a sense of mastery and virtuosity, and enables them to produce beautiful signatures, shapes, characters, and drawings with the confidence of an experienced calligraphist, graffiti artist, or painter. We were inspired by the flowing and empowering nature of the interaction and hoped to create a similar experience for the users of our installation.

Kung-fu and dance styles We were also inspired by the spectacular, powerful and flowing movements found in both martial arts and in different dance styles. We watched martial arts movies and a range of different dance performance videos, and contemplated how we could incorporate these inspirations into our installation. However, as our installation was intended to be used by the general public, we felt that dance and kung-fu moves would make the installation difficult to interact with. More importantly, this would require us to be very specific in our design in order to create a sensible user experience. It would require fine tuned control for the user, and therefore also extensive testing. We thought this idea had potential, but were not confident that we would be able to build it within the timeframe of the project.

Curious rituals: Everyday gestures and storytelling A large part of the movements and gestures we use daily are unconscious and automatic. The body just moves in response to intentions, thoughts, or external influences and events. We came across a very interesting website and ebook called Curious Rituals (http://curiousrituals.wordpress.com) detailing a range of different gestures that has emerged from people's use and appropriation of technology. Many of these gestures have come to carry meaning and significance, communicating state of mind, level of interest or awareness, availability, intent, etc. We were interested in exploring how different gestures could be used to communicate a message or tell a story. By incorporating some common gestures into our installation, we could play with their significance, sometimes producing feedback that corresponds to the gestures, while at other times creating unexpected and contradictory feedback that plays with the user's interpretation of the gesture.

However, an important challenge with gestures is that they need to be completed in full before their assigned function can be executed. This would introduce a disconnect, or delay, between movement and effect of movement that is problematic in an installation like ours. We wanted to create a more direct and immediate connection to the user's movement, enabling the user to experience the effect of their movement with as little delay as possible. Also, using specific gestures would warrant some explanation and guidance for uninitiated users, and would potentially demand a much more detailed technical design on our part.

Issues of fatigue and repetitive movements

The ergonomics of use of exertion interfaces are crucial for their success or failure. Through our exploration of different prototypes and functionality we quickly realised that there are important physical limitations to the kind of movements and poses people are willing to perform. For example, the use of repetitive movements is very straining for the user, and the strain increases with the frequency of the movement. This is a severe limitation to the design of virtual instruments that require the user to maintain a steady rhythm.

Also, holding the arms raised or even moving them in a way that keeps the elbows raised for more than a second or two quickly becomes straining on the shoulders and back. On the other hand, interaction that mainly relies on arm movement below the elbow, thereby allowing the elbows to remain lowered, is a lot less straining and can be performed over longer periods of time. We therefore decided to design the interaction in a way that allowed the user to interact with all the major elements of the installation without having to raise their elbows for extended periods of time.

4.5 The installation

Before going into the specifics of how we designed our installation, the following section describes its physical setup and functionality.

4.5.1 Physical setup of the installation

In all the locations the installation has been exhibited, the setup has been roughly in the way shown in figure 4.14. Each of the locations has had a size of at least a four by four meter area in front of the Kinect sensors. The installation consists of the following:

- A long and narrow table placed by a wall.
- Two Kinect sensors mounted on the table on top of each other.
- One Shake 'n' Sense device fastened to one of the sensors, as described in section 4.2.9.
- A wall-mounted screen, either a flat screen TV or a canvas lit by a projector.
- Two amplified speakers placed on the table on each side of the screen.
- Two Mac laptops placed outside of the installation area.
  - One Macbook Air running the audio system of the installation.
  - One Macbook Pro running the visual system of the installation.

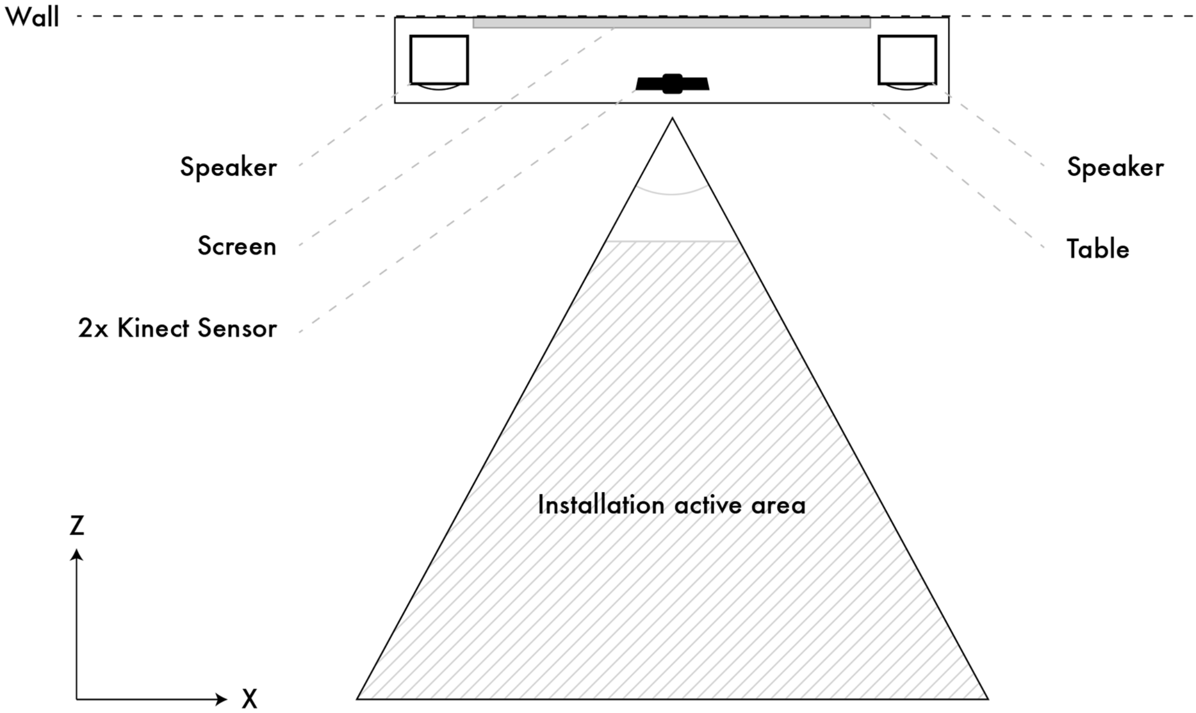

Figure 4.14: Physical setup of the installation

4.5.2 How the final installation works

The final installation consisted of two completely separate systems, one controlling the audio part of the installation and one controlling the visual part. These were tuned to work together and appeared for the user as a single installation.

Figure 4.15: The screen of the installation when in idle mode

When the system was in idle mode, meaning there were no people in its field of view, a triangle with an eye inside was shown at the center of the screen (Figure 4.15). The eye continuously scanned the room for users. At this point no sound was playing from the speakers.

Figure 4.16: The installation when in the process of calibrating a person

When there were no users currently interacting with the installation and a user walked into the installation's field of view, music faded in, the eye stared straight ahead and it and the triangle turned bright red while greeting the user with a text at the top of the screen, saying *"HELLO HUMAN, MOVE ABOUT"* (Figure 4.16). This meant a user had been calibrated and the installation went into active mode.

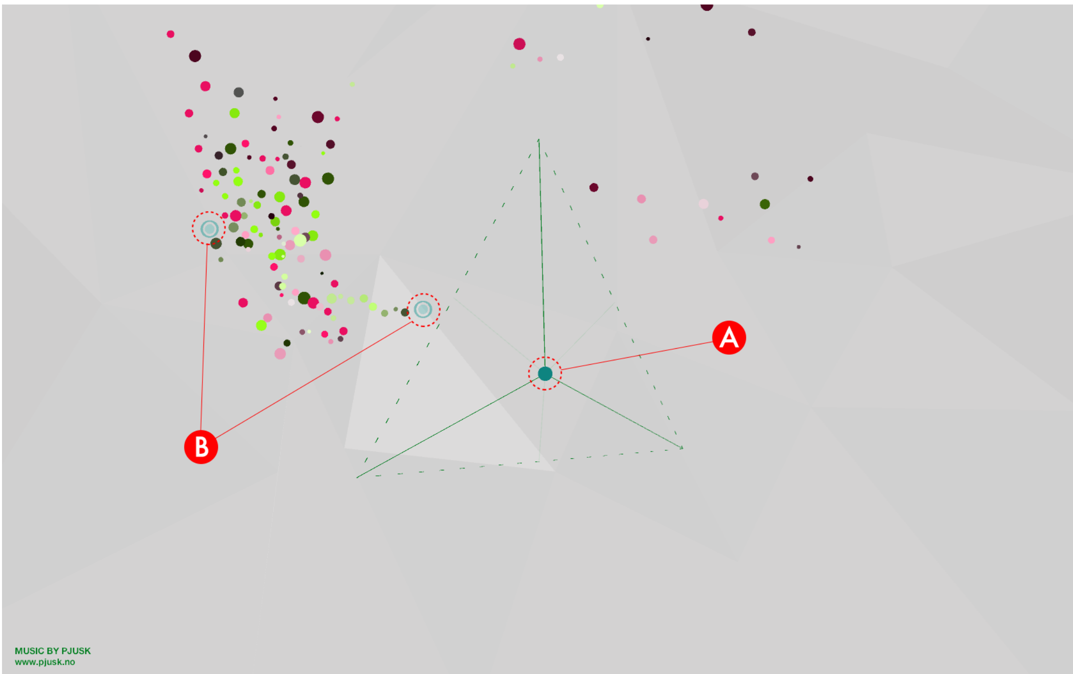

Figure 4.17: Installation in active mode with one user (A), both hands active (B)

In active mode, the triangle was analogous to the Kinect sensor's field of view of the X and Z axis (width and depth) of the room. The eye disappeared and displayed the position of the user(s) inside the triangle, represented by a coloured circle ((1) Figure 4.17). This moved when the user moved. As long as one or more users were present in the installation's field of view, the music continued playing through its loop of songs.

Interacting with the installation

The main way a user could interact with the installation was by extending an arm away from their body, or more specific, moving a hand a set distance from their neck. This distance was set to 25 cm, and works as a trigger for engaging audio and visuals. This interaction worked pretty much in the way of a computer mouse or touch screen-device. When the threshold was broken, this was interpreted by the system in the same way as pressing a finger to a touch screen. As long as the hand was beyond the threshold, the interaction was interpreted as the drag-behaviour of a touch screen. If the user pulled his or her hand close to the body, thereby again crossing the threshold, this movement is analogous to lifting your finger from a touch-screen.

When the position of the hands was beyond the threshold, a circular icon ((2) Figure 4.17) appeared on-screen at a position corresponding to the X and Y position of the user's hands. The circle was in the same colour as the user representation inside the triangle in the center of the screen.

Main modes of interacting with the installation

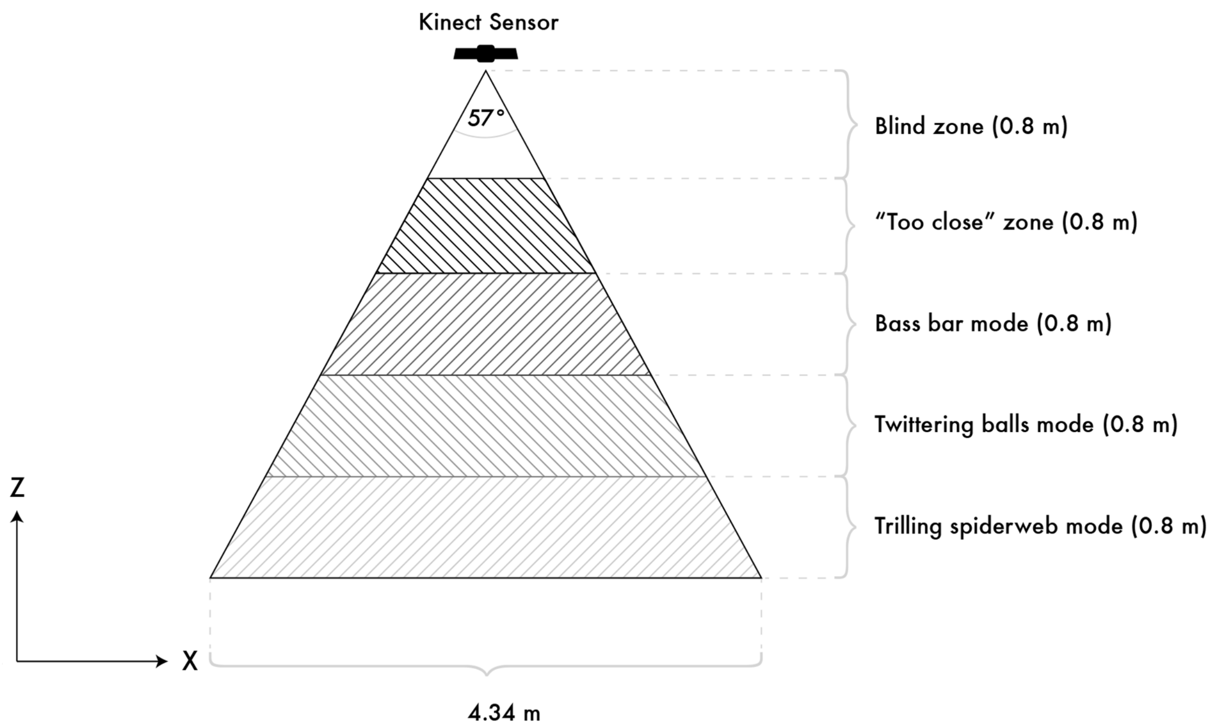

Figure 4.18: A top down view the mode sections in the Kinects field of view.

The installation had three main modes of audiovisual interactions. Each user's current mode was decided by their position along the Z-axis (depth) of the installation's field of view. This axis was split into three equal zones that contained one mode each. These three modes were as follows:

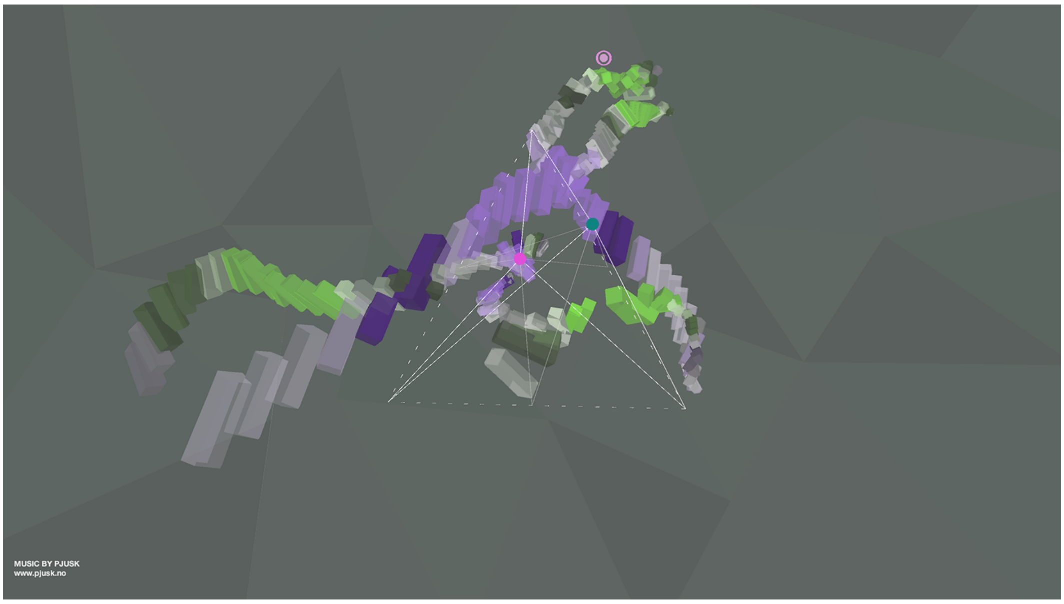

Figure 4.19: Two users interact with the 'Bass bar' mode

'Bass bar' mode The mode closest to the sensors and the screen was a mode where users could play distorted bass sounds while the movement of their hands generated a trail of multi coloured bars on-screen. The bass sounds were distorted and delayed to produce a kind of bouncing echo-effect, each triggered note lasting for approximately 10 seconds. Hand-movements re-triggered notes, layering them on top of each other and creating an increasing thundering cacophony of sound. If users retracted their hands, sound trickled out and the trail of bars disappeared one after another.

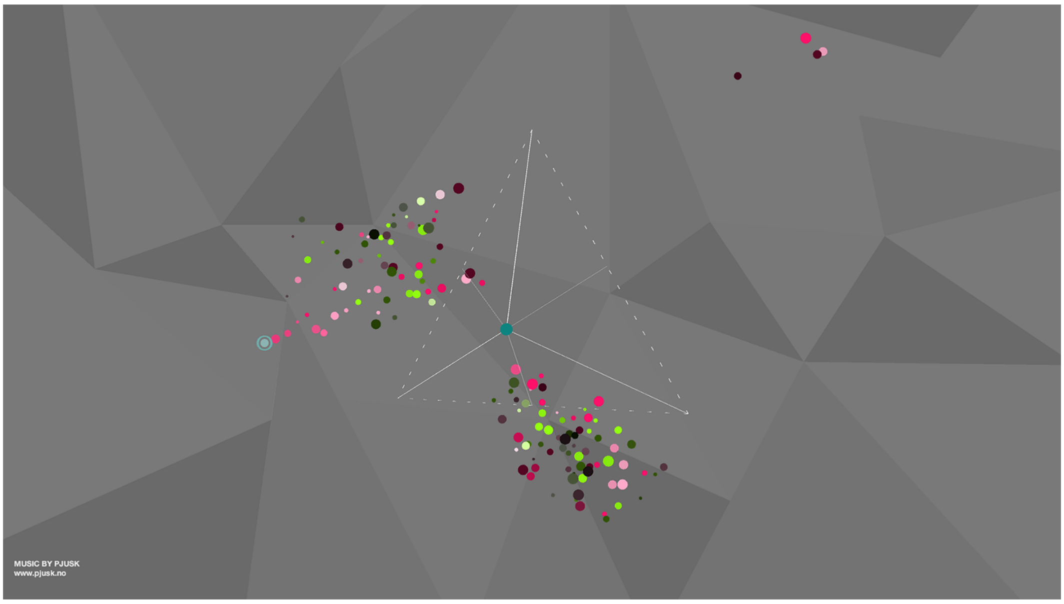

Figure 4.20: A user interacts with the 'Twittering bubbles' mode

'Twittering bubbles' mode When active, the middle mode consisted of an abstract sustained twittering sound accompanied by small particles or bubbles of variable size and colour, which were generated as a user's hands crossed the previously mentioned threshold. The sounds lasted for 8 seconds each and were layered on top of each other as the user retriggered new notes by moving their hands. The on-screen visuals were a part of a particle system that was controlled by a physics engine and the position of the user's hand functioned both as an emitter and a point of attraction for all particles currently visible on screen. This was the case regardless of which user had created them, so all active users could interact with and affect all visible particles on screen.

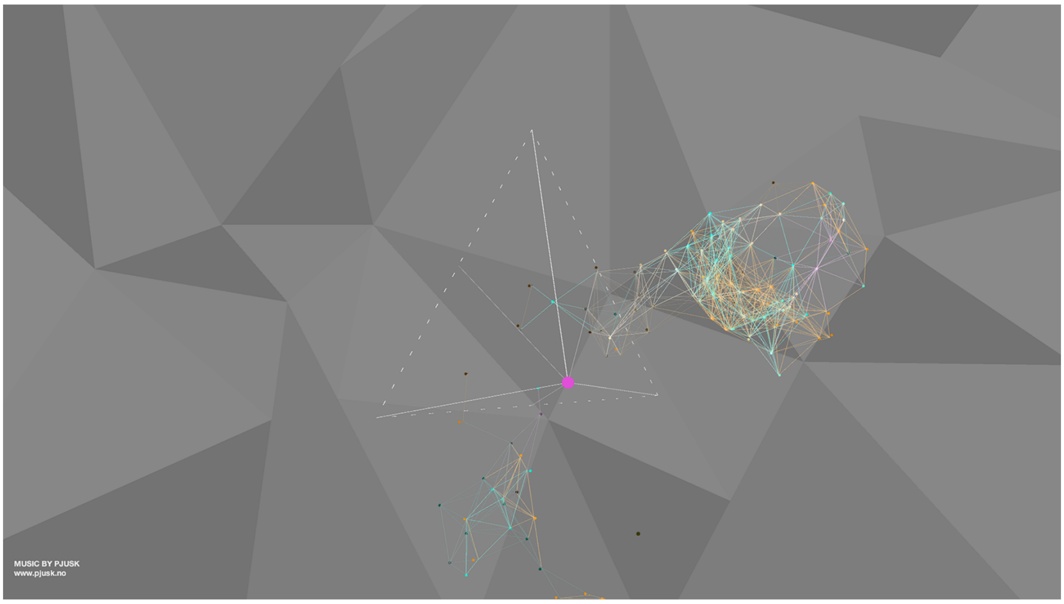

Figure 4.21: A user interacts with the 'Trilling spiderweb' mode

'Trilling spiderweb' mode The mode furthest away from the sensors functioned much in the same way as the middle mode, in the way that the visual system was based on a particle system affected by a physics engine and the user's hand positions. Visually the particles were small and of equal size and were connected by lines, forming a sort of organically moving spiderweb. The sounds accompanying the visuals can be thought of as a trilling sound ascending in pitch, almost like dragging a mallet from left to right on the keys of a xylophone. Each triggered sound lasted for 2 seconds.

In all modes, the volume of the sound generated was controlled by the Y position (height) of the hands. The higher the hands were held, the higher the volume of the generated sound was played. Also, the X position of the user's body determined the location of their sounds along the width of the interaction space, effectively following the users as they moved along the width of the interaction space.

Other modes of interacting with the installation

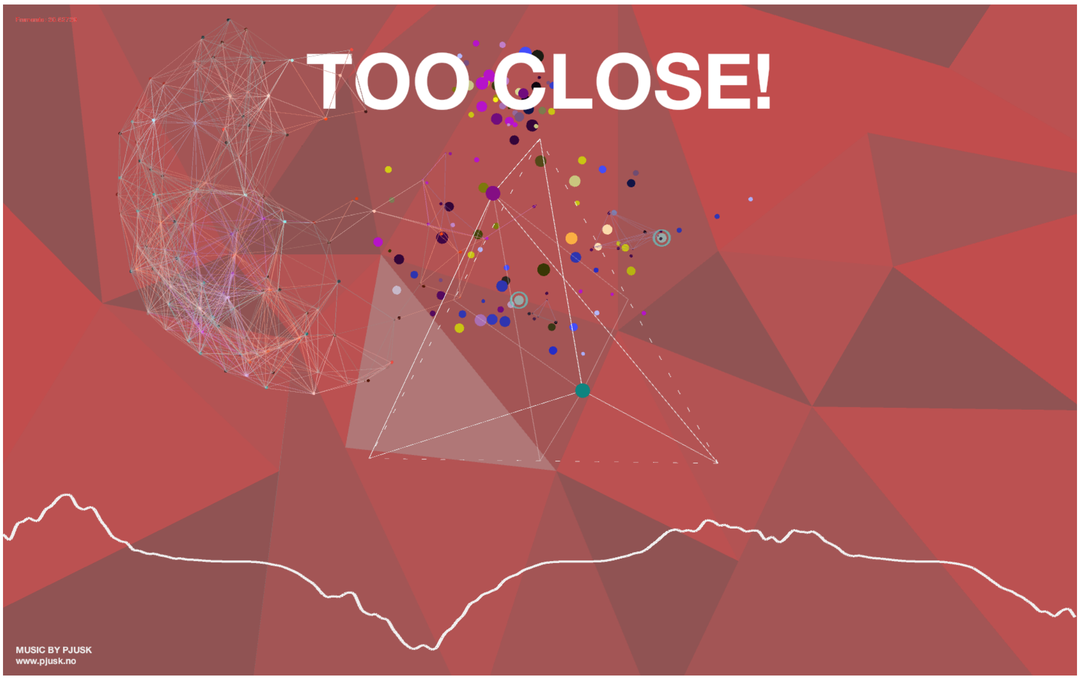

Figure 4.22: A user enters the 'Too close' zone

'Too Close' zone When a user was closer than 1.6 meters to the Kinect sensors, a text spelling out 'TOO CLOSE' appeared in large capital letters on-screen while the background flashed red. At the same time, the music slowed down and stopped in order to enhance the message that the user was moving into a zone where his or her presence is detrimental to the functionality of the installation. As soon as the zone was cleared of people the music started again and the visuals returned to normal operation.

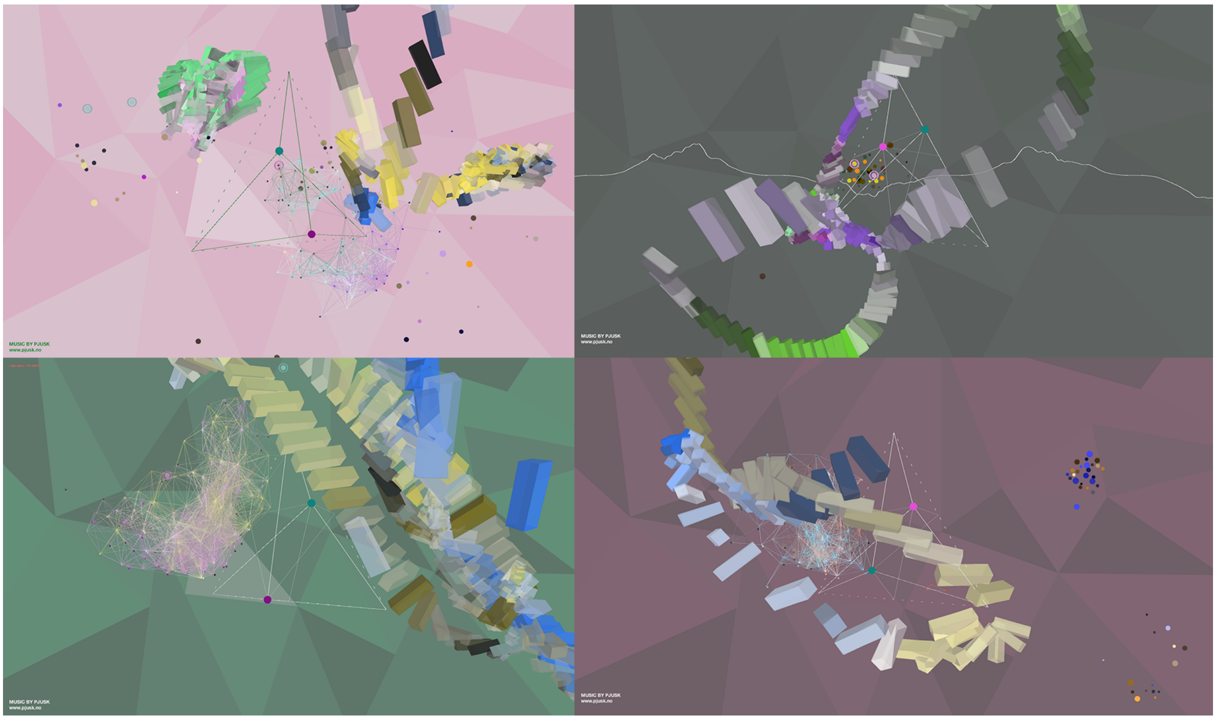

Figure 4.23: Examples of background colour generated by user position

Background colour There were two different modes of background colour in the visual part of installation: A warm dark and a warm light mode. The switching between these two modes was triggered by a predefined gesture of waving a hand towards the sensor and then moving the hand in a circle movement facing the sensor.

In addition, the colour hue of the background was generated based on the user's position in Z-axis of the Kinect sensors field of view. If there was only one user present in the installation, the background turned darker when the user was close to the sensor and lighter when further away. When two or more users were present in the installation, the position of user number one controlled the red values of the background, user number two controlled the green value and blue was an average of all users. This made the background shift in more strong colours than when only one user was present.

Slowing down the music By crouching down, a user could slow down the background music by 20%. If four users were crouching, the music slowed down by 80% (4 x 20%) of normal playback speed. For every user that stood up again, the speed would increase by 20% (of normal playback speed), and if all users rose again, the music returned to normal speed.

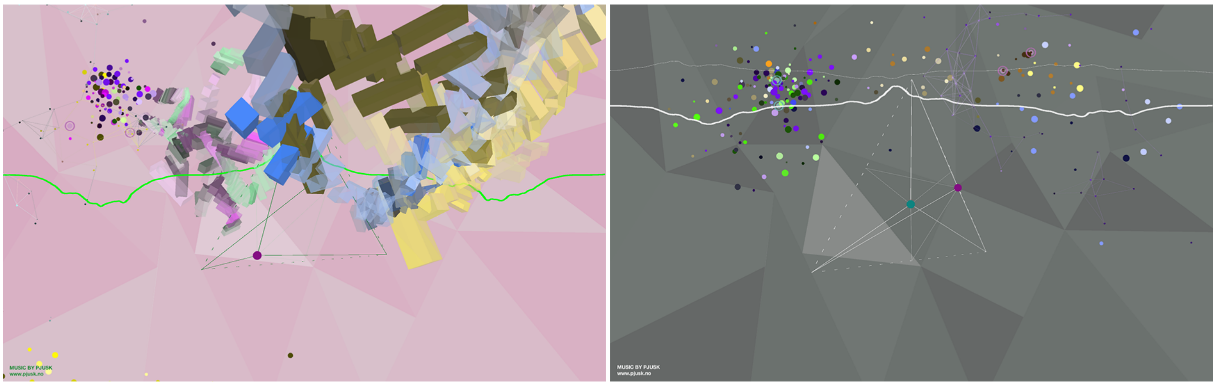

Figure 4.24: Lightning generated by users having hands in close proximity to each other

Lightning strikes If the hands of users came closer than 20 cm of each other, lightning rods would flash across the screen at the relative Y-position of the hands.

Colours of the main modes The colours of the user-created visual elements in the three main modes of the installation were generated according to the X and Z position (width and depth) of the user. The triangular field of view on the X and Z-axis was at the stage of testing divided into 28 equally large 80 x 80 cm squares. Each of these squares were assigned a base colour represented by a hexadecimal value. The colours the user saw on-screen were picked from a list of 150 shades of generated complimentary colours to the base colour of the square the user was currently positioned in.

4.6 Design of installation

4.6.1 A shared rule based fundament for audio and visual system

As discussed in the exploration of technology (Section 4.2), there was no direct connection between the audio and the visual parts of the installation. Even so, there were still connections, though these connections were entirely on a functional level. So before starting design and development of the final installation prototype, we needed to agree on this basic set of rules to create a common foundation for our separate systems.

Auto detection of users

As our intention was to create an installation that made its presence known and encourages users to interact with it on its own, the auto detection of users was essential. In earlier versions of the OpenNI drivers and its respective wrapper libraries, OSCeleton and SimpleOpenNI, a calibration pose was required to make the driver recognise a person. This calibration pose can be seen to the left in figure 4.11 on page 52. In later versions of the drivers, actually released during our exploratory phase, auto calibration were fortunately added. This was a great relief, as it enabled us to design the installation according to our intention of having the installation automatically detect people without them being aware of it.

Physical 3D space mapped to variations of 2D space

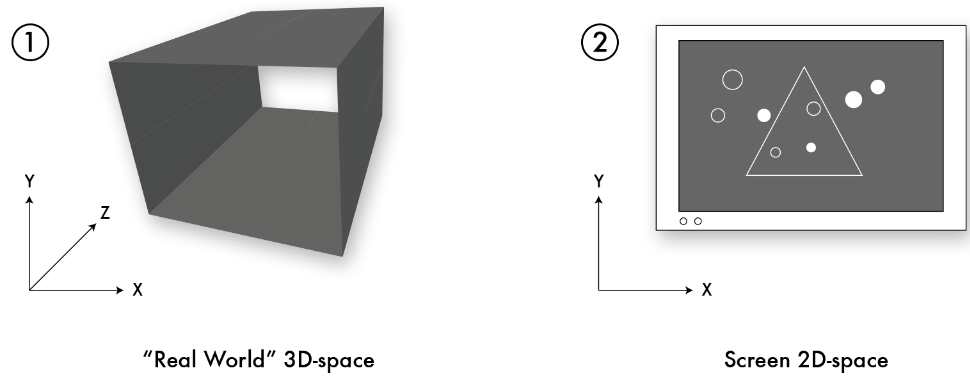

Figure 4.25: Axes of (1) 'Real world' 3D space contrary to (2) 2D space on a screen.

As mentioned, we experienced difficulties concerning working with visuals in 3D space, during the development of the 'Point cloud and button in space', 'Red line drawing' and 'Paint with 3D objects' prototypes described in section 4.3.1. After this, we decided on mapping two of the axes of the 'real world' space to the X and Y axes of 2D space available on a screen (Figure 4.25). This left us a third axis of the real world to be mapped to other functionality, for example by using this axis for trigger-thresholds for boolean functionality. For example the depth (or Z-axis) of a participants torso position in the real world was mapped to the height (or Y-axis) of the screen, so when a user moved towards the sensor or screen, their representation on screen would move upwards (Figure 4.17).

Kinect FOV as a common ground

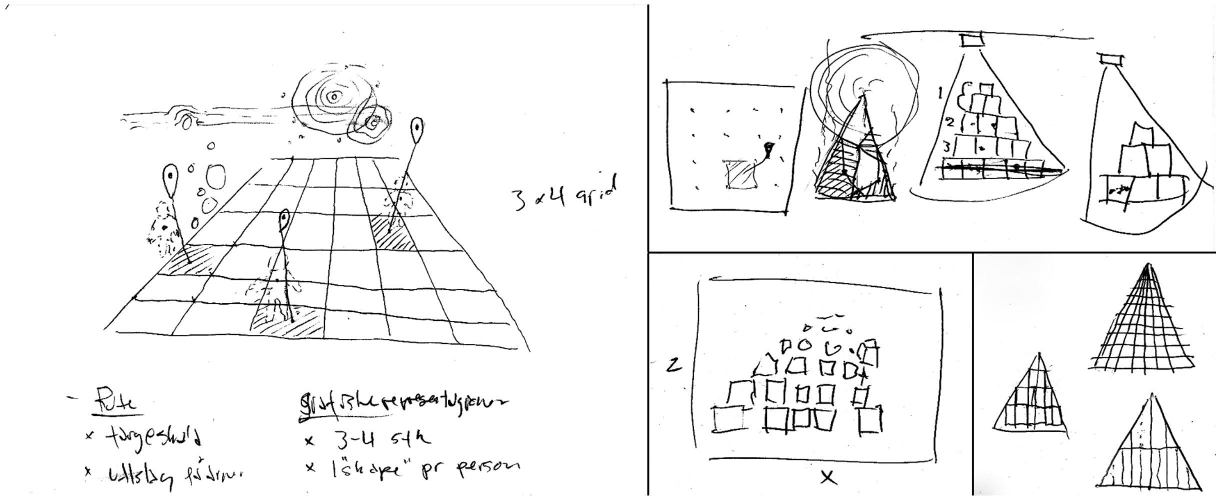

Figure 4.26: Process sketches of possible grid solutions, both visual and rule based ideas

To align and connect the three-dimensional space shared by the two systems we came up with the solution of a grid with tripwire-like mechanism for selecting functionality. This mechanism was the main connection between our two systems. The basic idea was to have it work in the way that the field of view of the Kinect sensors would be divided into a range of sections along the X and Z-axes, identical on both systems. These sections would work similar to buttons on an invisible keyboard laid out on the floor and select different functionality according to which section the participants' torso position currently resided in. The functionality for the section on each system should complement the functionality on the other one. A range of possible ways of dividing the space were discussed and evaluated, both technical alternatives and ways of representing this grid visually (Figure 4.26).

Grid The concrete implementation of the grid division of the Kinect's field of view was identical in both systems in respect to the Z-axis or depth of the area. These common divisions are the ones shown in figure 4.18 in section 4.5.2. However, along the width of the view, or the X-axis, the division differed in terms of how the mesh was laid out. The reasoning for dividing the width was based on technical differences in how the systems were built, and differing needs in how fine grained the grid needed to be to achieve the desired effects in the sound- and graphics- systems.

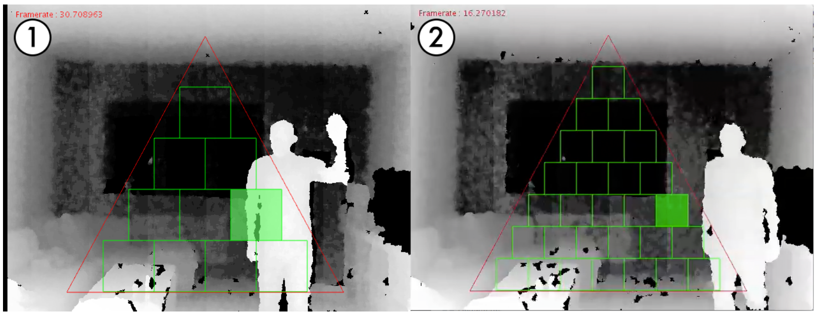

Figure 4.27: The Kinect sensors field of view divided into (1) 10 squares and (2) 28 squares grids . The opaque green tile marks the square in which a user stands.

Grid in visual system This grid was divided into equally sized squares stacked into a pyramid inside the triangular field of view as seen in figure 4.27. The 28 square grid was the one used in the final prototype. An early idea was to map different functionality to all of these squares, but because of the time constraints of the project, this notion was discarded. The only visible remnant of this in the final prototype was that the base colour of the elements generated by a participant are different for all squares. It was selected according to what square the participant's position corresponded to, as all squares on the same level were mapped to the same functionality. This mechanism was designed for interchangeability, so reordering and expanding functionality for the grid would be an easy task if one would wish to continue to further develop the prototype at a later stage.

Grid in audio system The grid in the audio system (Figure 4.28) was somewhat different from the visual system. Instead of equally sized boxes, the Kinect's field of view was sliced into eight slices along its width (X-axis). Due to the cone-shape of the field of view, the width of these slices grew larger as users moved away from the Kinect. Each of the slices were assigned different MIDI pitch-values that corresponded to notes in the C-major scale, like the white keys on a piano, starting from C and ending on the next C, one octave up. Additionally, the field of view was also divided into five zones along its depth (Z-axis). These corresponded exactly to the same zones that of the visual system, as described in section 4.5.2, and were used to determine which mode the user was currently controlling.

Put simply, the three zones farthest away from the Kinect functioned as oversized, invisible piano-keyboards, each zone controlling a different sound. By triggering each key within a zone from left to right, the *same* sound was played on each key, but with a rising pitch corresponding to the C-major scale. This grid allowed us to effortlessly experiment with a myriad of different sounds in Logic Studio without having to modify the underlying Max/MSP code. The remaining zones were: A blind area closest to the Kinect and the 'too close' zone, which acted as a buffer to keep users from entering the blind zone.

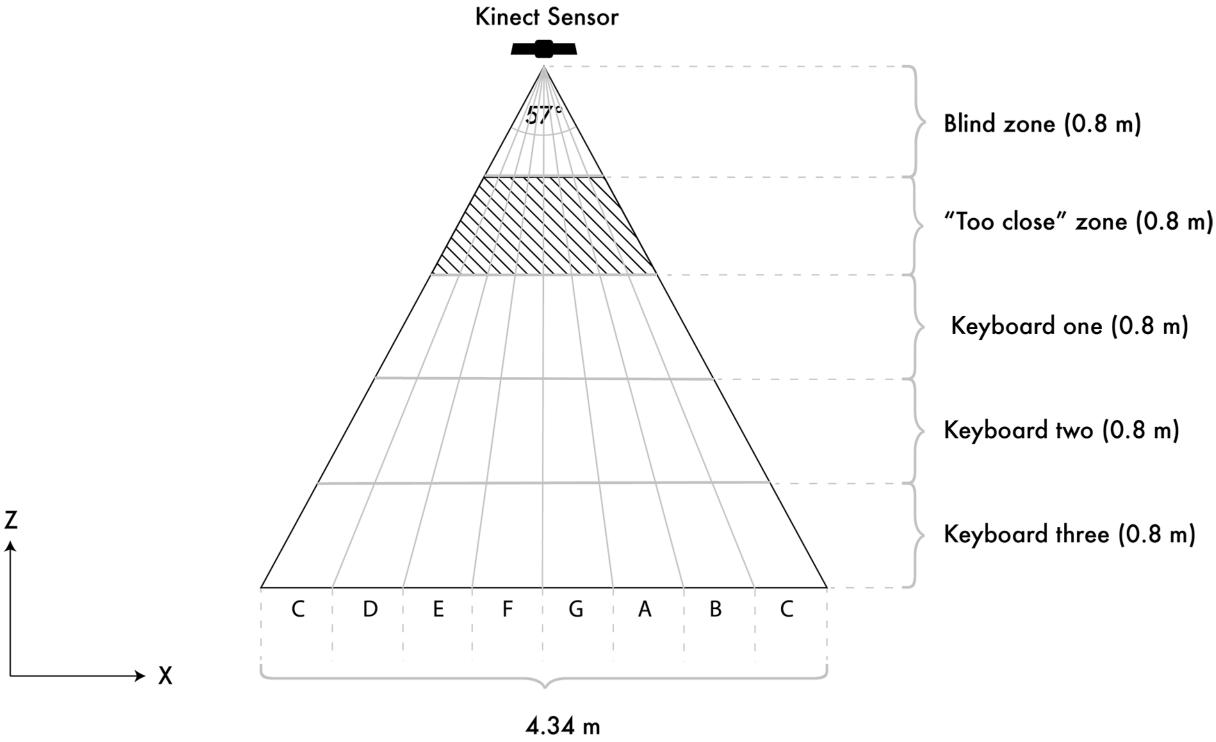

Figure 4.28: Grid of audio system

Hand triggers, threshold

The functionality determined by the user's position within our invisible grid was not evident to the user in any way without them actively triggering it. As there are little or no conventions or standards on how to implement triggering-functionality in exertion interfaces like the Kinect, we were quite free to define how we wanted this to work. Also, as we wanted our installation to give immediate responses to users movements, we felt that the most natural way for us to implement an on/off type of boolean trigger was to use the hand-to-neck threshold trigger method described in section 4.3.2. This would ensure that the trigger point never moved from the viewpoint of the user. In reality it hovered in the air in front of every user wherever they moved within the installation's field of view. All the users had to do to trigger functionality was to extend their hand a short distance away from their neck.

An alternative solution was to define static trigger-points directly into our grid, similar to the interaction explored in the 'Point cloud and button in 3d space'-prototype described in section 4.3.1. This way functionality would be triggered whenever the trigger points were 'touched' by a hand, elbow or hip, etc. This might allow us to cram a lot more trigger points into the interaction area, but would be very time consuming, especially considering that most of those points would have to be precisely aligned between the visual and audio parts of the installation. Also, as there would be no visual cues indicating the exact location of the trigger points, we felt that this could potentially be very confusing for the user.

Stateless systems supporting multi user interaction

As our two systems were designed to function completely on their own, a decision was made to keep the systems as stateless as possible. By stateless we mean that the systems did not keep or store any information on previous states or actions. This means that the systems reacted only to what a user was presently doing, and was not based on what has been done earlier by this user or any other.

There were several reasons for this choice. One was that developing a program that keeps and acts on this kind of information is a very time consuming task in terms of both programming and designing, as it requires a much more complex technical solution. This was also a part of the reason we did not want to make a game experience, since games in most cases requires states to be kept in some form to a greater or lesser degree. Our desire for responsivity was also part of this assessment. The actions induced by the participants of the installation should be visible and audible as close to real time as possible, and introducing the complexity required for keeping and acting on previous states could have noticeable effects on system performance.

Another important reason for the stateless choice is that we wanted the installation to allow multiple participants at once. However, since we chose to not have any communication between the systems, we had no way of ensuring that people were registered with identical user IDs by both systems. Neither could we be certain that a person registered by one system would be registered by the other system at all. This became evident as the audio system could only track a maximum of four people at the same time, due to a limitation in the Max-patch that provided communication with the OpenNI driver [51]. Furthermore, the Max-patch was set up to only receive tracking-data from users with OpenNI-user IDs #1 through #4, while the driver would register users with user IDs up to #10, meaning that anyone registered by the driver with a user ID above #4 would not get any audio-feedback from the installation whatsoever. The visual system, on the other hand, supported an unknown number of simultaneously tracked users, possibly as many as six [46]. Since users were free to enter, exit, and re-enter the installation, it became close to impossible to keep track of which participant were which and to keep some records of state even in a single system, and even more so across two systems that did not communicate.

Future proof code

The fundament of rules described in this section was not something that was visible to the participants of the installation in any way, but can be described as a kind of contract between the designers of the installation for the basic workings of both systems. We then continued to build our separate systems for visuals and audio according to this contract.

At the point of implementing this fundament, we did not yet have a fully developed concept for the functions and audiovisual expressions exposed to participants. It meant we needed to keep our code controlling the fundament independent and decoupled, from the future code of the parts exposed to participants. This enabled the creation of quick experiments and easy to swap or discard functionality (Section 4.6.2), without needing to change or risking to break fundamental code and interaction patterns common to both systems.

4.6.2 Design and development of final installation

Concrete concept - A eureka moment

At this point we had established a common ground for technical solutions and basic functionality of the prototype, as well as a common understanding of what we wanted to achieve with the installation, but we did not yet have a concrete concept.

The turning point came during an idea workshop in early January, where we went through a range of earlier ideas and some new ones of differing qualities. It was at this point we went to the web to look for further inspiration, and came across the Firewall installation (Section 4.4.1). We expressed our fascination for its simplistic beauty and atmosphere, until a point where the conversation derailed for a moment and turned to music and our common appreciation for electronica. A complaint was made of the lack of good new electronica in later years, where Rune mentioned he had a friend who makes electronic music in a duo called *Pjusk*, and proceeded to play this. Pjusk describes their music on their website in the following manner: *"The sound of Pjusk is inspired by the harsh Norwegian weather and wild landscape."* - (http://www.pjusk.no)

It's cold, abstract, dreamy atmosphere is something that we both are fond of. Suddenly an idea struck, of basing the concept of the installation, not on a concrete theme or function, but rather an abstract atmosphere or mood, complemented and supported by a piece of music. As we considered this thought, it dawned on us, why not use the music of Pjusk in our installation? With the music as a common denominator, the process went forward quickly, refining, iterating and experimenting with expressions in our respective domains of sound and graphics, while continuously aligning our systems.

The final concept

The concept or theme we decided to go for was then, in short, based on the atmosphere induced by the Pjusk album *Sart*, which means tender. This music would function as a sonic backdrop, while our installation would function as an audiovisual instrument complementing and affecting the music.

Both the sound and the visual landscape we wanted to create should be cool, soothing and beautiful, but also abstract. The primary reason for creating an abstract expression was to match the abstract form of the music, but also to prevent association to specific elements found in the 'real world'. Our notion was that this would avoid preconceptions and expectations among participants to how functionality and interactions should be.

Participants movements inside the space of the installation should induce different experiences according to their positions in the invisible tripwire system, and by this encourage movement in and exploration of the space. A scenario envisioned was when several persons would be active at the same time, they would not affect the installation in the same way, and in this way trigger curiosity among themselves and an incentive to discover more. To further encourage exploratory behaviour, explanations and hints in GUI and sound would be kept to a minimum.

Functionality as unified modes of experience

Having established the concept we set out to investigate our respective areas of responsibility on our own. An important keyword for us in this process was 'modes'. Since we divided the physical area of the Kinect's field of view into zones, 'modes' became our way of describing the combined behaviour of the audio and visual systems associated with these (Figure 4.18).

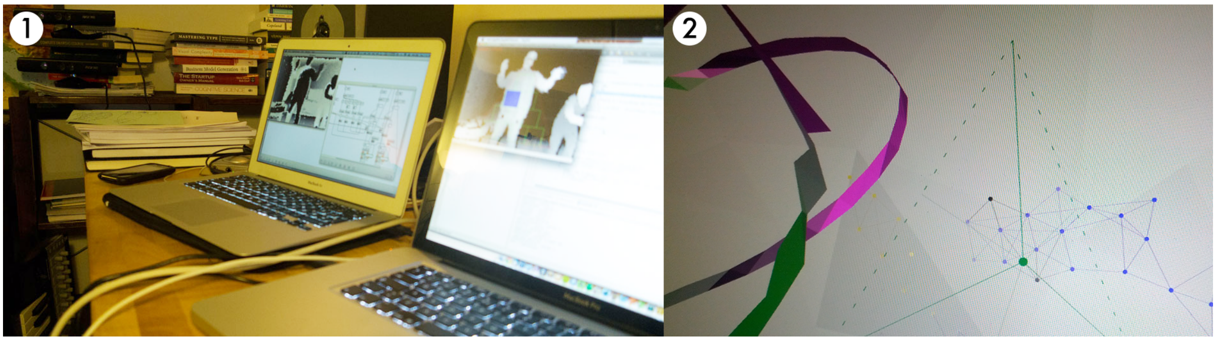

Figure 4.29: 1: Alignment of visual and audio systems in an early workshop. 2: Discarded mode, based on the 'Red line drawing'-prototype (Section 4.3.1)

We approached the design of these modes by exploring expressions and functionality, according to our areas of responsibility. These preliminary modes were built to integrate easily with the fundamental functionality we had developed. The continued process consisted of iterations of the following steps, where each iteration brought us closer to the installation (Figure 4.29):

1. Demonstrating the modes we had developed for each other.
2. Evaluating modes were by aligning systems and testing modes together.
3. Through subsequent discussion, modes were either refined to be included in the installation, discarded completely or prompted creation of new modes for the next iteration.

Design of visual system

The design of the visual system consisted of two main parts:

1. Defining the behaviour of the system when a participant interacts with a mode.
2. Establishing a consistent graphical expression for the visualisation of these behaviours and modes, as well as for the overall visual environment.

Establishing a consistent visual expression The visual expression we went for was to a great extent dictated by the limitations of the performance and tools of Processing, as mentioned in section 4.2.4. With these limitations in mind, we decided to go for a very clean and simplistic expression, focusing on heavy use of colours and movement instead of complex graphics. We were heavily inspired by 80ies computer games, where the graphic expression was also limited by the comparatively weak hardware and software of the time.

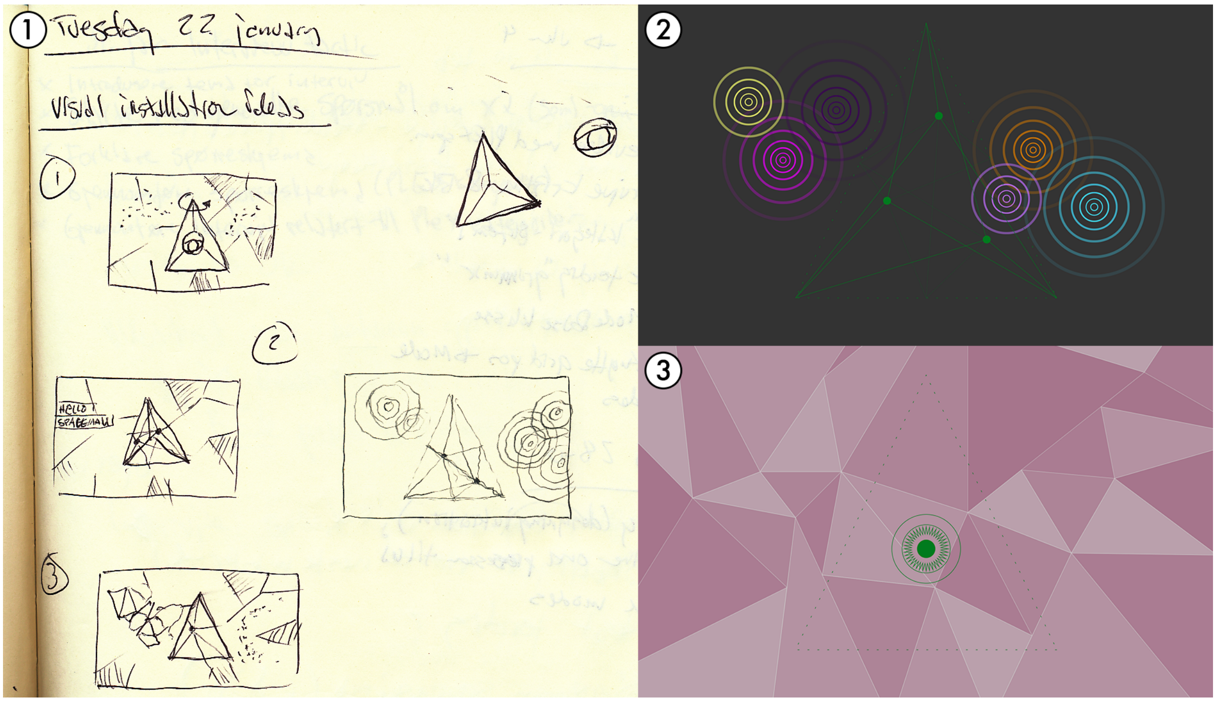

Figure 4.30: Visual ideas. (1) Early interface thumbnail sketches. (2) Digital interface mock-up from thumbnails. (3) Refined interface mock-up.

The visual system idea To keep the visual expression abstract, we envisioned using generative algorithms for creating the on-screen elements. We combined this with an idea from quite early on in the design process of using kinetic energy as a theme in the installation in some shape or form, which fit quite well. This meant we could create basic shapes and forms on the screen, like circles, squares and lines, and give them 'life' by making them behave vaguely similar to real world physical objects that could be interacted with by participants of the installation. From here we took to brainstorming on paper by sketching out suggestions for user interface, screen layouts, interface elements and visual styles as thumbnail sketches ((1) Figure 4.30). The idea-sketches that showed some promise were then recreated digitally in the vector drawing tool Adobe Illustrator ((2) Figure 4.30). These were then refined and expanded upon until the finished concept sketches were ready for implementation in the prototype ((3) Figure 4.30).

Link between participants and their screen presence We came to a realisation that we needed to give participants some visual cue to their presence in the field of view of the Kinect sensors, to establish a connection between them and their on-screen presence, as well as to hint at the fact that they were actually involved in the installation.

This resulted in the creation of a stylized version of the width and depth space (of the grid system, seen in figure 4.27). Its representation took the form of a slowly revolving triangle in the center of the screen, where participants' position would be continuously represented by a sphere assigned a colour linked to the specific user. This representation can be seen as (1) in figure 4.17 in section 4.5.2. Lines were drawn from the spheres of the participants to the corners of the triangle and to the midpoints of its edges. These lines were not meant to have any direct link to functionality, but served to create a sense of connection between the participants presence and the space available for them, as well as creating continuously changing and overlapping patterns inside the triangle when participants moved about. It was also thought that the lines also could help amplify the awareness of movement, so participants more easily could make the connection themselves and their on screen presence. Additionally the positions of a participant's hands had to be indicated in a clear way, but without intruding too much on the generated graphics. We chose to solve this by showing semi-transparent circles, filled with the same colour as the participants' sphere ((2) Figure 4.17). These circles were only shown when a participant's hand was extended beyond the threshold for activating a mode.

Attempting to catch the attention of participants through visuals In order to entice potential users to interact with the installation it was necessary to come up with some interesting and conspicuous graphics to display in idle mode. We landed on creating a large stylized eyeball situated inside the revolving triangle, intentionally referencing the look of the 'All seeing eye of God' or 'Eye of Providence' as something mystic and with the hope of triggering curiosity. This eyeball appeared to rotate at quick intervals, stopping only to focus at something in the room before continuing to scan its surroundings. When the Kinect sensor spotted a human-like shape and attempted to calibrate the person, the eye and its surrounding triangle were coloured red. In addition, the text *"HELLO HUMAN, MOVE ABOUT!"* was displayed in large red letters to further heighten the awareness of potential participants to the fact they were seen, and their presence was actually causing this to happen.

Screen as a canvas The rest of the screen real estate was intended to act as a blank canvas for the visual behaviours triggered by the participants. To give the canvas a feeling of depth and space, we created a background texture, consisting of white triangular polygons with different transparency values to overlay a flat background colour ((3) Figure 4.30). In this way we could change the background colour easily and keep the illusion of space created by the texture, without changing the texture itself. The background colour itself was generated based on a participant's torso position in the grid or the combination of all positions if several participant were present in the installation.

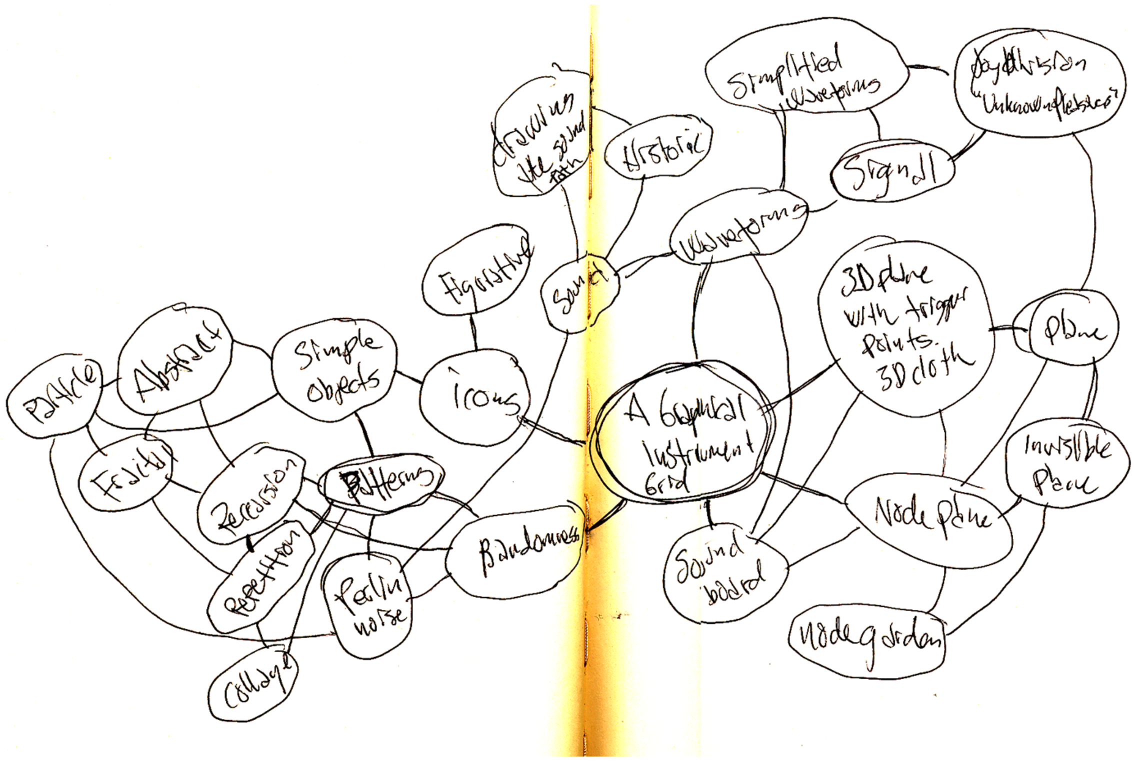

Figure 4.31: Mind-map of ideas for types of visualisation in a 'Graphical Instrument Grid'

Defining behaviour of the modes To identify suitable behaviours for the modes of the installation we conducted another brainstorming session where we mapped out different types of algorithms using a mind map (Figure 4.31). A significant part of the consequent process consisted of quickly creating modes with the algorithms most likely to be appropriate and then testing them with the audio system, as described in section 4.6.2. This also meant consulting a myriad of online tutorials, books and Processing libraries on generative algorithms. The most prominent of these are discussed in section 4.2.4.

When a participant triggered a mode by extending her hands, generative algorithms was used to create a continuous stream of graphic elements on-screen. Each of these elements were assigned a behaviour defined by a range of parameters, among others like vector speed, mass, attraction or repulsion force and field size. The subsequent behaviour was controlled by participant interaction, in conjunction with a particle physics engine from the toxiclibs library called VerletPhysics, that emulates selected laws of physics through algorithms. The physics engine affected all on-screen elements in the same mode, independent of who had produced them. This enabled participants to affect elements created by others through programmed attraction fields (virtual magnetism) mapped to their hands. This enabled participants to create unique visual expressions through motion, either on their own or through interacting with others.

'Twittering bubbles' and 'Trilling Spiderweb' mode These two modes were the results of several iterations with experiments of particle systems and particle physics described above. The general idea behind these two modes was to enable participants to interact with and abstract shapes and forms, and at the same time give the impression that these abstract forms had a life of their own. Both modes operated in a similar fashion, but with some defining differences.

The complete area of the screen was defined through code as a 'world' affected by the laws of a physics engine. Circular shapes were continuously added to the 'world' at the position of a participant's hand when the hand crosses, or activates, the trigger threshold. Each shape was given a repulsion behaviour, as well as random time of life in the system. The repulsion behaviour was defined by a field of repulsion, the size of this field along with the strength of this repulsion. The participant's hands on the other side were given a field of attraction, larger and stronger than the repulsive forces of the unique elements, so the effect on screen were that elements newly created or previously present at the hand position would cluster to the position of the hand. When the hand was retracted from beyond the threshold, the attraction would disappear, and all elements would violently push away from each other. These behaviours were all calculated by the same physics engine, controlling the velocity, acceleration, repulsion and attractions of all elements, so when more than one participant were present in the same mode, they could affect the all elements present, and through this interact with each other through the system.

The main difference between these two particle-based modes was the amount of force assigned to the elements of each mode. This still resulted in a quite dramatic difference in behaviour. Additionally, the 'twittering bubbles' (Figure 4.20) were of random size, while the 'trilling spiderweb' (Figure 4.21) elements were of the same size, as well as becoming connected in a web of lines, if in close enough proximity to each other.

'Bass bar' mode The 'Bass bar' mode (Figure 4.19) was the last mode to be completed and was in essence a drawing tool, although we made efforts to camouflage it as such. It had its origin in the small prototypes 'Red line drawing' (Section 4.3.1) and 'Paint with 3D objects' (Section 4.3.1) described earlier, and in contrast to the two other modes, it did not include any behaviour similar to real world physics. We decided to evolve the basic functionality used for the red line and 3D paint prototypes, keeping the idea of drawing a path on screen according to hand positions in 3D space. The path itself was invisible, but rectangular, semi-transparent boxes were spawned continuously along it, as long as the participant's hand was beyond the triggering threshold. These boxes rotated slowly around their center point on all axes, at the same time as the full path were slowly tilted at random intervals. If a participant held their hand still, this resulted in quite massive squirming clusters of edges, looking almost alive as the bass sound rumbled along in the same tone. If instead the participant used large hand movements, it became obvious that one could control the placement of the boxes, while at the same time creating variations of the bass tones.

The creation of these modes was the result of a lot of experimentation through adding, adjusting and re-adjusting parameters in code for sizes, speed, rotation, colour, transparency, physics, movement on screen relative to participant movement and perspective. Then afterwards, aligning audio and visuals to ensure a coherent experience. In the end we felt the outcome of visuals and audio combined gave the desired effect in the installation we were aiming for.

Programming the visual system

This section will give a very brief insight into how the visual system works from a programmer's perspective. The development of the final prototype of the visual system was primarily done over a six to eight week period in the beginning of the last six months of our project. Additionally some lesser improvements and changes were made during the subsequent period of evaluating the prototype, based on the feedback of the participants. At this point we had spent almost six months exploring prototypes and technology, which enabled us to complete the last programming sprint rather quickly.

Processing as a game engine To get an understanding of how the final prototype operates, some further insight into how the draw-method of processing works is needed. As mentioned in section 4.2.4 describing Processing, the draw-method operates as a simple game loop. This means that Processing runs this method as many times as specified by a certain value each second, or as close to this value as the computer's hardware allows, this is also called a 'frame tick'. This mechanism can be thought of as the mechanics of filming with an analogue camera: A film strip consists of a range of frames played back in quick succession, and for each fraction of a second (often 24 or 30 fractions per second), the camera has to capture a new frame on the film strip. The draw-method works pretty much in the same way. It has to make computations on the data available and then draw the appropriate elements to screen to create the impression of movement. In the case of our prototype, it has the frame rate of 30, meaning the draw method runs as close as possible to 30 times each second.

The code As the codebase of the final visual system prototype consisted of 3840 lines of code in total, counting only codes inside methods and excluding whitespace

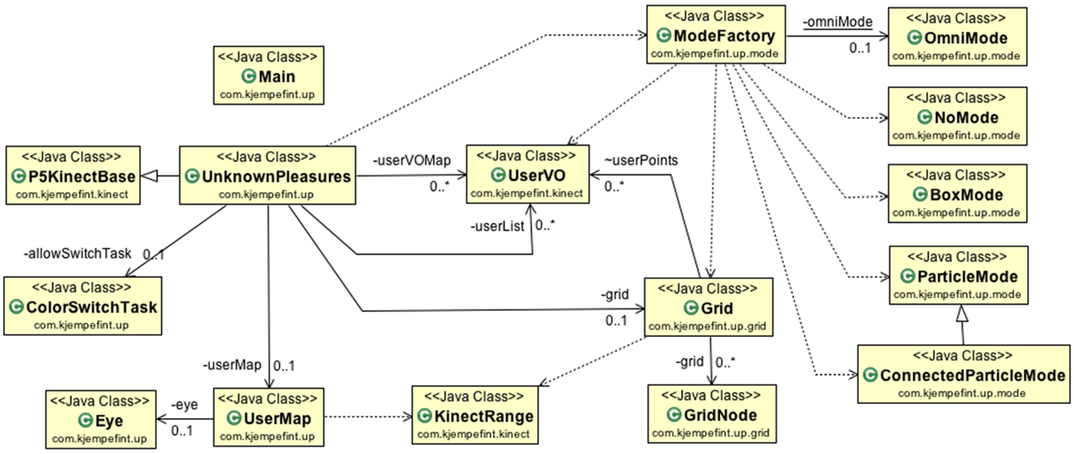

Figure 4.32: Class diagram of the visual system.

and all third party library code, this will be a very superficial and quite simplified presentation of the inner workings of the visual system application. Figure 4.32 shows an overview of the Java classes handling the main functionality of the application. Not shown in this diagram is the range of utility-classes, value object classes and the third party libraries. The libraries used were the following:

- Processing (http://processing.org/)
- toxiclibs (http://toxiclibs.org/)
- simple-openni (https://code.google.com/p/simple-openni/)

The main classes and their responsibility An overview over the subsequently described classes and their connections can be seen in figure 4.32.

Main The Main class is the entry point for a Java application. All it does is start the program in full screen.

UserVO UserVO is a class holding information of the current state of a participant, or 'user' as used in the lingo of the programming conventions. This class includes positions for neck, torso, left and right hand, current mode, data associated with user in current mode and current colour assigned to user according to position. The UserVO class is treated as a kind of currency that is distributed around the system, so the respective classes can change or act upon the information it contains according to their responsibility.

P5KinectBase Inherits the base class of the Processing library. By this it makes available all the functionality of Processing to us in the Java program. In addition it initialises and makes available the Kinect sensor through the simple-openni library.

UnknownPleasures This is the main class of the application, which in essence runs the installation. It inherits the functionality of the P5Kinect base class, and implements the setup and draw-methods discussed in section 4.2.4, on Processing. In the setup-method, all system variables are initialised and configured according to preference. For each call to the draw-method of this class, it processes all data from the kinect, and from this creates a list of UserVO objects representing the participants or users currently in the installation. The list is distributed to the Grid, UserMap and ModeFactory-classes to compute the information, before it draws all the graphics on screen according to these computations. Then it repeats this process over and over again, until the application is exited.

Grid The responsibility of the Grid-class is to find which square of the grid ((2) Figure 4.27) a user's torso-position corresponds to on the floor level.

UserMap The UserMap-class creates and controls the triangle in the middle of the screen and everything displayed within, including the animated eye when the system is idle. When the system is active, it produces the visual version of the grid of the Grid-class, with the spheres representing the users positions.

ModeFactory The ModeFactory does as its name suggests, it creates, displays and controls the modes that are active according to the values of the UserVO-classes and the map of grid positions of the Grid-class.

The mode classes All the mode classes implements an interface called IMode. This interface ensures that the rest of the application does not need to know of their inner workings and that all modes can be treated alike, in accordance with the principle described in section 4.6.1. The 'Bass bar', 'Twittering bubbles' and 'Trilling Spiderweb' are represented on the visual side by respectively the BoxMode, ParticleMode and ConnectedParticleMode classes. But there are two more modes also in existence. The NoMode ensures that nothing happens where it shouldn't, as in the 'too close' zone. The OmniMode is responsible for behaviour that is shared in the whole field of view of the Kinect-sensor, for example the horizontal lightning created when two hands of users are close to each other.

Notable challenges The challenges in the development of the final prototypes were several, but most notable were the creation of the parts for creating and controlling the different modes and the problems that arose around enabling multiple users to interact within the same mode. This required some clever software system design and needed to be rewritten several times before it ended up as satisfactory. Also, since the system reacted only on what happens *now*, as in the data available in the current draw-method call, it meant some state would have to be kept for the modes to work, even if our intention was to keep the installation stateless. This keeping of mode-states was absolutely necessary for the installation to work as we envisioned, but we suspect some of the instabilities still present in the final system was caused by memory leaks associated with keeping this data in memory. The part of the programming that took the longest time was the building of the application's fundament according to the rules outlined in section 4.6.1, although it did not pose challenges of the sort we experienced when developing the mode parts of the system.

Design of audio system

The design of the audio system consisted of four main parts:

1. Design grid system based on earlier prototypes
2. Development of music playback system
3. Exploring sounds to match visuals and music
4. Parameter mapping - pan and volume, speed of music

Design of grid system The grid system was based on work done with earlier prototypes, as described in section 4.3.2. The main template-prototype was the 'air piano'. This formed the internal grid, or keyboard, in each of the three zones, and provided the 'hand to neck' trigger method for activating sounds. We added some code that changed the channel of the MIDI-output from Max when the users crossed certain thresholds in the Z-axis (depth). We also set up different software-instrument tracks in Logic Studio that each was receiving MIDI messages on channels corresponding to those output from Max. This enabled us to quickly switch the sounds assigned to the different zones, or modes, without having to modify any code. The result of this structure for the users is that the sounds they trigger with their hands are selected on the basis of their distance from the Kinect. By aligning the distance thresholds with those of the visual system, we were able to change sounds and visuals relatively simultaneously whenever a user crossed over from one zone to another.

Development of music playback system Max provides tools for fine-tuned control of audio playback. One of these is the 'groove '-element, which allows seamless control over playback speed and volume, among others. We set up a system that would continually loop through a list of songs (the album *Sart* by Pjusk). We developed some code that faded the volume up whenever someone entered the field of view of the installation, and faded it back out when the last person left. In this way the installation would be completely quiet as long as no-one used it, but would fade in the music whenever a user was identified. The intention was both to have a conspicuous but not intruding way of audibly acknowledging the presence of a user, as well as avoiding polluting the immediate environment with continuous sound output.

Additionally, the ability to control the speed of playback was used for two different purposes. First, in addition to the visual warning produced by the system when the user enters the 'too close' zone, we developed some code that would turn the speed of playback down to a full stop over a period of one second. The effect sounded about the same as stopping a vinyl-record playing on a record player: The music quickly slows down and stops. This underlined the visual message that the user was moving into an area that was detrimental to the functionality of the installation. Secondly, we used the same speed control mechanism to create a way for the users to influence the music. This was implemented as a kind of hidden 'easter egg' that was activated through lowering one's head below a certain threshold. This had the effect of slowing down the music.

Exploring sounds and visuals The established grid structure now made it easy to experiment with different sounds, and to explore how they worked in conjunction with the different visual elements. We tried a range of different instruments and samples of various kinds, from common and recognisable instruments like pianos, guitars, drums, flutes, through samples of speech, animals, weather, traffic, to synthesised sounds and ambient soundscapes.

The most challenging aspect of sound selection was to find sounds that, on one hand, were distinct enough to be separated from the music, but on the other hand didn't overpower or dominate it. We wanted to create a balance where the sounds and music complemented each other, producing a sense of harmony between them. Also, by designing sounds that somehow sounded like they were emanating from the visual elements themselves, we hoped to tie music, sounds, visuals and user movements closer together, creating a more immersive experience that transcended the 'sum of its parts'.

We had learned from earlier experiments with the 'air piano' prototype that using familiar instruments carried certain significance for the user, often resulting in attempts to play the instruments musically. However, we did not want users to think of the installation as a musical instrument. Pjusk's music is an abstract, floating and alien atmosphere, consisting of artificial and electronic sounds. Apart from one song where an acoustic guitar is used, none of the sounds used in the music can be tied to any familiar instruments. It was therefore important for us to try and design sounds that fit the Pjusk sound, making it possible for the users to connect with the music in some way through their movements.

Affordance of music Music affords movement. It coaxes and coerces its listeners into nodding their heads, tapping their fingers, pumping their hands and so on, and most of us do it automatically whenever we hear music that we like. This movement usually follows the beat or rhythm of the music. However, we did not want to design a system that would require the users to repeatedly perform the same movements in order to hold a steady rhythm. This would quickly become straining and exhaustive, making the users less likely to want to use it for more than short periods of time. Also, as the installation allowed up to four people to interact with it simultaneously it would quickly result in an uncoordinated cacophony of sound where maintaining a steady rhythm would be very difficult.

Pjusk's music is well suited in this regard due to its complete lack of normal rhythmic and percussive elements like drums. The music slowly floats and pulses rhythmically on its own without any sort of traditional beat. This way the music affords calm and flowing movements instead of fist-pumping and head-banging, leaving room for us to create sounds and visuals that complements the music.

The sounds controlled by the users were based on common instruments. We relied heavily on a range of different audio-effects in Logic Studio to distort them beyond recognition. Different reverberations and delays were used to sustain the sounds for several seconds, making it possible to layer sounds on top of each other by constantly retriggering new sounds before the previous had died out. The resulting sounds seemed to 'spray' out continuously as the users retriggered them by moving their hands. We were hoping this would match well with the way the visual elements seemed to spray onto the screen, and induce a different kind of movement compared to instrumental sounds. Instead of a chopping and repetitive movements in order to play rhythmically, we hoped this would create more flowing and continuous movements. However, by layering the sounds they quickly grew to an unpleasant cacophony if their reference volume were set too high. It was therefore crucial to find a balance between the music and the user-generated sounds so that neither overpowered the other.

Parameter mapping In addition to simply triggering different sounds, we wanted to create a way for the users to continually control the volume of the triggered sounds. This was basically done by mapping the sum of the height (Y-axis) of the user's two hands to the volume. By tweaking and testing we were able to find a range that allowed users to raise the volume to maximum by either holding one hand slightly above their heads, or both hands at chest height. Lowering both hands below the hip would turn the volume down to almost inaudible.

Finally, a basic feature of all audio production software is the ability to pan sound between two loudspeakers in a stereo-configuration. We mapped the user's X-axis position directly to the pan of the track currently being controlled by the user, creating the effect that the sounds would follow the user from one side of the installation to the other. However, the effect was hard for the user's to notice themselves, because the sounds always appeared to be in front of them. Also, when several people were using the installation there was so much sound going on that it was hard to distinguish them from each other. We experimented a little with different ways of tweaking it to make it more obvious, but eventually decided to just leave it as it was and see if users picked up on it.

4.7 Prototype evaluation

4.7.1 Purpose

The purpose of the prototype evaluation sessions consisted of two distinctly different goals. The first goal was for the evaluation to be a part of the design process, both to validate what we had done, but also to improve and evolve the installation. This meant locating obvious usability flaws in the installation, to see if what we created had a viable future at all. This would allow us to observe users encountering the installation for the first time, identify potential problems, and to familiarise ourselves with how users behaved while using it. Furthermore, by interviewing the participants about their experiences with the installation, we wanted to dig deeper into their understanding of their experiences and identify elements that contributed to make them pleasurable. These findings, both in terms of UX and usability, were then used as a basis for continual improvements during the three weeks the prototype evaluation lasted.

Secondly, we intended these sessions to make us better prepared to interpret the observations we were going to do in a public context. So before installing our system in a public setting it was important for us to test it on users in a controlled private setting, to have a basis for comparison.

4.7.2 PLEX survey as interview script

We prepared a survey based on the PLEX framework and used it as a manuscript for the rest of the interview. The survey contained 21 questions, one for each experiential dimensions in the PLEX framework, such as *community, challenge, exploration, suffering*, etc. The only category we added was *context*. Context was added as a category since it is considered a crucial factor of user experience. The participants were asked to evaluate to what extent they had experienced those dimensions in their use of the installation. The alternatives were: 'none', 'some', 'moderate', 'high', and 'very high'. In other words, the participants were asked to reveal to what extent their experience gave them a sense of community with something or someone, to what extent they felt challenged, and to what extent they felt that the context influenced their experience, and so on.

After making their selection, the participants were asked to rate the importance of the feeling for the total experience. The intention was to get the participants to discuss which of these aspects were important to this particular experience, and which were unimportant and negligible. Here we only gave three alternatives: very important, moderately important, or not important. Once they had selected their answer, we asked them to elaborate on the reasoning for their selection and discuss it among each other. This way they were allowed to make up their mind individually before hearing what the other had answered. We repeated this process for all 21 experiential dimensions.

It is important to point out that even though the PLEX framework took the shape of a survey in our evaluation sessions, the intention was never to use the quantitative data gathered to draw conclusions, but it was meant as, and used as a way to initiate discussion around the topic of enjoyable user experiences.

4.7.3 Test of evaluation methods

Before doing the evaluation, we wanted to do a dry run of our interview technique, the list of interview questions and to test the usefulness of our PLEX survey as a manuscript for discussion. Each of us enlisted the help of a friend to serve as interviewee, and used the survey to interview them about a computer game of their preference. This should be a game participants were familiar with, and enjoyed playing. We did not, at this stage, want to conduct test using our installation, as the aim of the test was to test and develop the actual evaluation process. The two games chosen by our friends were Bubble Mania and Civilization 5. The games are very different, and it was interesting for us to see if the PLEX survey would be useful as a tool to explore both experiences, or if there were any shortcomings that would be problematic for the evaluation of our prototype. It would also allow us to test the usefulness of asking the interviewees to rate the perceived importance of each theme. We acknowledge that our installation is not a computer game, and that there is no guarantee that the survey will work for our installation even though it works for these games. However, we felt that these test would give us a general impression of the usefulness of the survey as a tool for investigation into user experiences.

Our extensive list of prepared questions did not work very well, as they seemed forced and did not stimulate much to reflection on the interviewees' experience. On the other hand, we found that the survey worked remarkably well in both cases as a basis for interviewing people about their gaming-experiences. The most important lesson was that by having a list of themes instead of pre-formulated question, we were able to engage the interviewees in open discussions about the themes. The interviewees would by own initiative ask questions about the themes in order to clarify what they implied, before reflecting on the themes out loud, and thus actively engaging with the subject matter, allowing us to naturally steer the conversation onto the areas we were most interested in.

4.7.4 Evaluation setup

Location and physical setup

Location The tests were conducted in the UX-lab at the Institute of Informatics at the University of Oslo. The UX-lab is a fairly large, white room of approximately 7 x 10 meters, which contains:

- 7 Tables of different sizes and heights.
- 8 Chairs.
- An assortment of computers and screens.
- Miscellaneous projects and hardware.
- 1 Cupboard/cabinet with a range of hand-tools, electronics, materials, etc.
- An old 1950s-style sitting-room set, including sofa, table, cupboard and books.

- 1 Flipover.
- 1 Large whiteboard.
- 1 Roof-mounted projector w/canvas in front of whiteboard
- 2 Stereo wall-mounted speakers on either side of screen/canvas.
- Blendable windows on the wall opposite the screen.
- Dimmable lights.

We chose this location for our experiments for several reasons. First of all, it provided a complete setting for both experiments and interviews, allowing us to quickly transition from experiment to interview while the experiences were still fresh in the mind of the test subjects. Secondly, access to the room is restricted, providing a controllable environment free from external noise and disturbances. Third, all the necessary technical prerequisites for the installation were easily available, reducing the amount of rigging needed to prepare for the evaluation. And finally, it allowed us easy access to potential expert test subjects in the form of interaction design students.

Setup The room gave us ample space to set up our installation and all necessary:

- A wide and shallow table under screen / whiteboard, holding 2 computers, each connected to a Kinect. The Kinects were placed below and in horizontal centre of screen, facing out into the room, one above the other.
- 4 x 4 m of free space in front of the screen.
- 1 Large table with four chairs for post-test interview.
- 1 Video camera on a tripod behind the interaction-zone, facing the screen/installation that was used to capture what was happening on-screen during experiments.
- 1 Wide-angled video camera in front of the screen, facing out into the room, that was used to capture test subjects interacting with installation.
- 1 Hand-held camera focused mainly on the test subjects.
- 1 Directional microphone on a tripod table stand, connected to a portable audio recorder, that was used to capture audio during experiments and interviews.

Selection and recruitment of participants

Expert testers We wanted to start the evaluations by conducting two sessions with people familiar with experimental design, prototyping and user testing in order to get informed and qualified feedback on both our installation and on the entire evaluation setup. A major point of involving domain experts was their experience of working with unfinished prototypes and seeing past their obvious flaws [26]. It would also allow us to do necessary adjustments to our setup before inviting other participants to whom the experience would be more foreign and intimidating. Our so-called expert testers were two pairs of fellow interaction design students. We also invited a pair of professional interaction designers to conduct a third test. Unfortunately, one was prevented from attending, which resulted in the third test being conducted with only one participant.

Amateur testers As amateur testers we enlisted two pairs of friends. When inviting them, we were very clear on the importance of them giving their honest opinions, and that they would be doing us a disservice if they gave us answers they thought we wanted to hear.

4.7.5 Description of execution

Upon arrival, the participants were each given an *informed consent* letter, explaining the purpose of the evaluation, that we would record both video and audio during the session, how we intended to use the data, that their privacy would be respected, and that they were free to terminate their participation at any time. They were also instructed to use the installation as long as they wanted to, and to stop whenever they felt bored or lost interest. We gave no descriptions about what we expected them to do. The only significant difference between the expert and the amateur tests was that the amateur testers were not asked to evaluate our execution of the session or the PLEX framework.

Observation of use

Before the participants entered the lab, the lights were turned off and the window blinds were shut to prevent daylight from coming in. The cameras and audio recorder were started and synced, and the installation was started and allowed to enter standby-mode, ready to react to anyone entering its field of view. As the participants entered, the installation responded to their presence and the test would go from there. We observed and selectively answered questions from participants, depending on what the questions were and how they related to the subject matter.

Semi-structured interview

As soon as the participants were done exploring the installation, they were invited to sit down at the table at the opposite end of the room. We opted to interview the test subjects together for several reasons.

The evaluation session was meant to be a shared experience, and we felt that by interviewing them together we would allow the participants to re-live the experience together and discuss it freely, as one would with a group of friends. We acknowledge the possible bias this involved, but this is partly why we chose to invite testers that knew each other, as they were more likely to engage in, and dare to disagree in discussion. The alternatives were either to separate them and conduct one-on-one interviews concurrently, or to let one test subject wait while we both interviewed the other. The first alternative was a real option, as it would prevent the test subjects from influencing each other's answers. However, it demanded access to two separate rooms, and more importantly, it would make it difficult for us to ensure that the interviews were conducted equally. We also felt that the one-on-one setting would be more formal and awkward for the test subject, which could potentially limit the richness of their response. The second alternative was out of the question as it implied that one of the test subjects had to wait for upwards of an hour before being interviewed. That would not only be a waste of their time, but would also give them time to digest the experience and pass judgements in a way that the other test subject couldn't. We also felt that it would be beneficial if we could both be present at all the interviews. This would ensure that we both had the same relation to the data and would make it easier for us to evaluate and discuss it later.

Short introductory discussion The interview started with some very open general questions about first impressions, positive or negative, and suggestions for improvements. The primary purpose was to allow the participants to steer the conversation and let them talk about whatever they felt a need to talk about. This way it would be easy to get the conversation going, and expose their most immediate impressions of the experience. We would then ask them to elaborate on topics we found interesting,

PLEX survey After the initial discussion, we would present the PLEX survey and continue to go through the themes, as described in more detail above (Section 4.7.2. After finishing the survey, we wrapped up with a short discussion of the whole process and answered any questions the participants might have.

4.7.6 Coding and analysis of the data

The data from the interviews conducted in these sessions were first transcribed into full text. Through borrowing techniques from grounded theory we coded the transcripts using open-coding, identifying topics of interest (Section 3.1.3). These topics were then analysed and sorted under key types of statements made by participants, before re-coding the transcripts based on these statements. What we found were statements describing:

- Experiences (Positive, negative and neutral)
- Desires
- Behaviours and actions
- System (The installation)
- Context

Finally, we asked the data a selection of questions, based on what we wanted to find out through the evaluation sessions. The answers to these questions resulted in the findings described in the next section:

- What did the installation succeed in?
- In what terms did the installation fail?
- How could the installation be improved?
- How did the participants describe their experience?
- How did the participants want their experience to be?
- How was the experience related to the private lab context?
- How might the experience be in an *imagined* public context?

4.8 Findings - Prototype Evaluation

Our findings from the evaluation sessions are split in three: Evaluation of the installation with the intention of iterating upon and improving the functionality as a part of the design process; evaluation of the participants' user experience; and an investigation of how the context affects the user experience.

The use of the installation by the participants of these evaluation sessions differed some in duration. The expert use sessions lasted for respectively 15, 15 and 23 minutes, while the amateurs tested the installation for respectively 19 and 36 minutes. The two expert sessions on 15 minutes were stopped by us, as parts of the installation crashed. This greatly exceeded our wildest expectations, as we imagined they would endure five minutes at the most, if we were lucky.

The quotes in this section have been translated from Norwegian to English. We have tried to keep the quotes as close to their original meaning and oral form as possible. This has produced some quite cumbersome and grammatically incorrect sentences that require a little concentration to fully understand. We apologise for this, but felt that it was necessary in order to stay true to the original data.

4.8.1 System (Assessment of installation)

What did the installation succeed in?

Before starting the design process we declared some clear goals concerning what type of installation we wanted to create. These are listed in the introduction of this thesis, section 1.1. According to these stated goals, our findings indicate we succeeded in the following areas.

Fun The main goal of the installation was to create something that was enjoyable to use, and the participants described several aspects of the installation as such, among them the aesthetics of the installation and the process of exploring.

> *It was fun. It was fun seeing it. It was fun hearing it. I think this is the core of it. That it's sound and visuals, you move about. You apply many of your senses, and that's fun. That's what makes it exciting.* - Participant 1

> *Exploring is what* is *fun about it [the installation]* - Participant 8

> *In the beginning it was all a mystery, and then you would just have to explore and figure everything out. Everything was unknown, the exploring was fun, that's the 'thing' about installations like these.* - Participant 4

A prominent aspect of the installation described as fun was the immediate response it gave to the participants' physical movement:

> *Very cool. In the beginning it was fun that it [the installation] reacted to you at all. First it was just fun, but then you start looking for systems. 'Does it affect on the music?' 'Does it affect the visualisation?'* - Participant 3

> *[It was] Fun to move about and to see what happened* - Participant 2

Exploration Our main intention of how the installation was to be used was through exploration, and all participants of the evaluation sessions were in agreement on this point.

> *I experienced this as the main point of the installation.* - Participant 3

> *This was the main thing about the installation, exploring the system and the functionality.* - Participant 6

> *It is just exploring, really. Until you feel you master (the installation) a bit, then it's really exciting and makes you want to continue. You never know if you have explored everything and that's positive, you never reach an end.* - Participant 1

Playful The installation was by most participants described as playful.

> *I looked at it more like something playful than something exciting.* - Participant 8

> *I didn't manage to control everything I tried to control. You didn't need control to steer something - it was more to play around. If you had a goal of steering something, I had deemed it much more important. Here it was more like, you touch something, it spreads out and 'wooiii', you get a good feeling.* - Participant 8

> *I spent almost all my time on exploring and making stuff happen, that's what was fun, to explore and to play a bit. For this type of installation I think this is very important, because it's playful.* - Participant 7

Open-ended

> *The mystic, imaginative, exploring part was quite important to me here. The abstract is something you have to interpret on your own and create your own imagery.* - Participant 7

> *The openness of the installation is an advantage, what you are competing in is left to your own interpretation.* - Participant 1

Aesthetics As mentioned in the design process, our goal for the aesthetics was to keep both sound, music and visuals as abstract and different from 'this world' as possible. This was to keep participants from bringing preconceived expectations on how things should look and function into the installation and to leave as much as possible up to their interpretation. At the same time we wanted to create an as coherent sensory experience as possible. Our attempt was in large part verified in a positive manner by the participants, emphasising the abstract and the coherence of the audiovisual expression.

> *It was quite atmospheric with the music and the things that happen when you do stuff. The sounds created a good ambiance.* - Participant 7

> *I liked the music, and it fit well with the graphics.* - Participant 4

> *It's good to keep it abstract. If you compare it [what is depicted or heard] to reality, the threshold for what would be accepted would be much higher.* - Participant 3

> *I don't think it would have been better if the sounds were separated distinctly from the visuals. The music added a subconscious dimension, but was a part of the whole.* - Participant 4

> *Stylish abstract animations.* - Participant 9

> *The whole thing [the installation] is very abstract. [...] The visuals contributed to making it incomprehensible and exciting.* - Participant 2

> *I was, in a way, inside a fantasy world, it was very different. [...] I would say it was very important for my experience that it was different. It was cool that it was an abstract world. It would have been quite boring if this were a virtual living room.* - Participant 9

Discovering, understanding and learning The opinions were split among the different participants on this topic. Most argued that 'not getting it' at once is the whole point, and by providing too much cues would ruin the installation, as the topic is closely related to exploration.

> *By providing more information one might reveal the illusion that there is more to discover.* - Participant 2

It leaves less to explore then. If you make it more understandable, then you take away the whole of point the installation. - Participant 3

If you show the zones [of the modes], you might get the feeling of having 'beaten the game'. - Participant 1

As mentioned, the opinions on this were not unified among the participants. A few found it difficult to understand how the installation was supposed to work.

I see that it reacts to movement, but I don't understand much else. - Participant 5

[The installation] It is not suitable for people that gives up easily and does not like to explore. - Participant 1

Discovering something is not the most important thing for me in these types of installation. Having something to fiddle around with and being immersed is. - Participant 9

In what terms did the installation fail and how could it be improved?

Control Along with progression, the absence of control was something the participants frequently mentioned as a weak point. In the light of this, not giving a stronger focus to user control may be considered as a failure on our end.

I wish there were a higher degree of control. - Participant 9

It was a bit disappointing that I did not always get the response for the system that I expected - Participant 7

Although some participants acknowledged that they achieved a certain degree of control and mastery, the lack of control was frequently connected to the inability to create and put something of themselves into the installation.

If the installation had been a commercial 'thing' out in a public space I would have expected greater precision and ability to create something. This is very important because it [the installation] shouldn't be perceived as frustrating, since I think people wouldn't be bothered to use it then. - Participant 7

The ability to create through having control was also linked to the potential of cooperation and the chance of getting into a flow state.

I felt I did not have enough control to create something constructive. If you could create some music together or something, it would be more creative. I think this is really important, because a greater opportunity to be creativity would make me more immersed in the installation. - Participant 9

Progression In these evaluation sessions, the impression was that the functionality was quite hard to comprehend in the beginning. As the participants understood how the installation worked, they wanted more functionality to explore and discover, since exploration was deemed the key element of the experience.

> *I want more things to explore, that something new happens, a change in the environment. My interest disappears when I feel there's nothing more to discover.* - Participant 4

> *I missed having more challenges to work with. For example finding easter eggs, a world that evolved, the visual expression could have changed when you did something. Colours, background etc. Now it just stayed the same.* - Participant 4

> *It had been more exciting if you could manage three steps: First you just play with it (the installation), then you see correlations and then you create your own expression through applying what you have learnt.* - Participant 3

To facilitate the installation for people less persistent in their exploring, it was suggested to make basic functionality more easily accessible and instead increase difficulty over time:

> *I think a more understandable functionality with a lower bar of entry would make it [the installation] more interesting for kids and others that might think it looks difficult. Then you could create progress through introducing new elements and make things gradually harder. Enable mastery in the beginning and frequent level increases.* - Participant 9

Cooperation In four out of the five evaluation sessions we conducted, pairs of participants evaluated the installation. These participants expressed a desire for more cooperation through the installation.

> *It could be interesting to have some functionality that demanded cooperation.*

> *The installation could be improved by facilitating cooperation.*

Competition A few of the participants described themselves as competition-focused and expressed a desire for a competitive element. Although they admitted it was not an important aspect of an installation like this, it was described as an optional area of improvement.

> *Could surely have been fun with a competitive element, so you did better than your opponent. But it's not important here.* - Participant 3

> *What could have been cool since we are two persons, with the dots and everything, at first I thought you should try to steal dots from each other. Maybe then you were allowed to decide more tones or something. To have some competitive element or something.* - Participant 4

4.8.2 User (Assessment of UX)

This section will give an overview of how the participants described their experiences. This implies returning to some of the themes already mentioned above (Section 4.8.1) as these are central to the participants' experiences. However, this section will focus more on the experiences and less on the features of the installation.

Progression Progression emerged as the single-most important aspect of the participants' experiences. This was not a theme we explored explicitly in our questions, but when talking about other aspects of their experiences, participants frequently described these aspects in terms of how they contributed to a sense of progress (examples are given under the respective themes). Lack of progress was also the most important reason for boredom and loss of interest:

> *I felt that I came to a point where I couldn't get any further, and started losing interest* - Participant 5

Goals Having goals was also central to the participants' experience. There were some conflicting statements regarding the need for goals, but their importance for the experience cannot be neglected. One participant indicated that the lack of clear goals was confusing and frustrating, contributing negatively to their experience:

> *I think goal achievement is important, but didn't feel that I achieved anything.* - Participant 5

Others said that having goals were not important to them:

> *It's a creative game. Not important to feel that you've finished it.* - Participant 1

> *The goal is to explore it. I stopped looking for problems to solve.* - Participant 3

However, as with progress, when talking about other aspects of the experience, goals were frequently used as a way of understanding those other aspects. Several also indicated, directly and indirectly, that the lack of clear goals made them invent their own goals:

> *I created goals for myself, but didn't get a direct sense of achievement. Didn't know what they were, so I had to create them myself.* - Participant 9

This indicates to us that goals are instrumental in providing a sense of progress and direction to the experience.

Discovery / Understanding / Learning When presented with an unknown and completely nonsensical installation like ours, participants naturally tried to make sense of the experience by exploring it, looking for patterns. Discovery and understanding were used as motivations for continuing to explore the installation, providing a way to gauge the progress:

> *I was able to put a few pieces in their place and that's very important because it gave me new motivation to continue.* - Participant 5

As such, discovery and understanding became the goals of the experience, providing the necessary motivation to engage with the installation:

> *The goal was to find new things to do, to understand how things worked.* - Participant 4

When they had exhausted most of the ways of interacting with the installation and stopped discovering new functionality they felt frustrated and bored:

> *The frustration transitioned into boredom because I felt I had cracked all the codes there were. Started with the attitude that 'I'm going to complete this', but ended with a little resignation and disillusionment from not getting anywhere.* - Participant 5

Exploration As already mentioned, most participants identified exploration as the main purpose of the installation. When talking about exploration as an aspect of the experience, it was mostly described in positive terms:

> *Fun to explore possibilities.* - Participant 1

> *You're looking for patterns. The fact that you don't understand anything is motivating.* - Participant 1

As already mentioned, some became frustrated by the lack of depth to explore:

> *I want more things to explore, that something new happens, a change in the environment. My interest disappears when I feel there's nothing more to discover.* - Participant 4

Control Several users expressed some frustration over the lack of control they had over the experience. This made it difficult for them to be creative, and contributed to a sense of confusion:

> *I didn't feel I had enough control to be able to make anything constructive.* - Participant 7

> *I was a little frustrated by not having complete control of what was going on.* - Participant 8

Others were less bothered by the lack of control:

I didn't feel I had enough control. The lack of control wasn't frustrating, but set limits to what you could do. - Participant 3

I didn't manage to control everything I tried to control. You didn't need control to steer something - it was more to play around. - Participant 8

Most participants indicated, indirectly or directly, that lack of control at some point had a limiting or negative impact on their experience.

Challenge A sense of challenge also had an impact on the participants' experience. But as the installation didn't provide any specific challenges for the participants to overcome, they mostly expressed challenge in terms of understanding, discovery, control and progress. When asked specifically, most of them stated that they didn't feel particularly challenged by the installation in any normal sense:

The game itself is not challenging [...] The challenge is to understand it. - Participant 2

I wasn't challenged or forced to develop any new skills. It was more like experimenting. The goal was to find new things that you could do, to understand how things worked. - Participant 4

Competition The participants seemed to relate to the theme of competition in two ways: Some had strong competitive instincts and expressed a need to either compete with their co-participant or with the installation itself. Others had a more cooperative inclination:

I felt pressure to find new functionality before [co-participant]. Wanted to 'steal' [co-participant's] dots and sticks (referring to visual elements) - Participant 2

I felt a competition instinct to explore everything, to beat the machine. - Participant 1

I didn't experience competition at all. I was thinking more about cooperation. - Participant 3

Others again had feelings of both competition and cooperation:

I didn't feel I competed with my co-participant, but I admit wanting to understand it before him. - Participant 1

Thus competition serves as a way to formulate goals to work towards, providing a way to conceptualise and gauge progress.

Cooperation / co-creation / interaction / fellowship As already mentioned, cooperation and competition are related to each other. They are to a certain extent opposites, but can co-exist to some degree:

> *Given that there was no obvious competition element I felt that the point was to cooperate and play.* - Participant 5

Like competition, cooperation provides a way for the participants to understand and discover how 'things work'. By cooperating, the participants were able to explore the system more methodically by directing and talking to each other:

> *Watching the other person added a level of excitement, and made it easier to understand how things are connected.* - Participant 3

But given the lack of clear purposes and goals, both cooperation and competition had to be constantly refocused and reformulated by the participants, either internally or amongst each other. The open-ended nature of the experience made it difficult for them to maintain a sense of direction with regards to both competition and cooperation:

> *There was a certain feeling of fellowship given that we were two [participants], but there was no obvious way for us to play together. I saw that the dots maybe were kind of connected. Maybe I should have had a sense of fellowship, but I didn't understand anything.* - Participant 6

Flow Flow can be seen as a sort of opposition to self-consciousness and shyness. As mentioned in section 2.4, flow involves letting go of yourself and becoming completely involved and immersed in the activity. Several participants described their experiences in similar terms:

> *I didn't think of anything else at all, while we were doing it. It's important that it catches your attention and makes you want to use it. I also forgot that we were being filmed. It was a mental break.* - Participant 3

> *For some reason I entered a kind of mode, it felt really very good, kind of relaxed in some way* - Participant 4

> *I forgot that we were being filmed, was very 'lost'* - Participant 2

> *With the music in the background you get a little mesmerized* - Participant 2

> *It struck me halfway through that I wasn't focusing on the music at all. I was so preoccupied with the visuals.* - Participant 3

Fun Participants frequently used words like *fun*, *cool*, *exciting*, *neat*, *amusing*, *etc* when describing the experience:

> *Pretty exciting.* - Participant 1

> *Very cool.* - Participant 3

> *Fun to move and see what happen.* - Participant 1

> *I spent most of the time trying to explore and discover things. That's what was fun.* - Participant 8

Despite describing their experiences in these terms, the participants also underlined that this was not enough to keep them interested:

> *It's fun to use, but I don't get a sense that I'm creating something.* - Participant 2

> *Very cool. In the beginning it was fun that it [the installation] reacted to you at all. First it was just fun, but then you start looking for systems. 'Does it affect on the music?' 'Does it affect the visualisation?'* - Participant 3

Aesthetics The participants frequently commented the aesthetics of the experience. There were positive statements like:

> *Lots of visuals, great.* - Participant 1

> *It's a very comfortable experience.* - Participant 3

> *I liked the music, good sounds, and it fit with the graphics.* - Participant 4

And more negative statements of displeasure:

> *It went in the same tone the entire time. I didn't get any sense of calm from the monotony. It influenced my experience negatively.* - Participant 5

Frustration Frustration was a feeling that often came up in relation to the themes of control and understanding:

> *I was a little frustrated by not having full control over what was going on* - Participant 8

Some of the participants had an ambivalent attitude towards frustration:

> *If you don't feel any frustration, it's hard to feel challenged.* - Participant 1

> *Frustration contributes to the challenge, but is annoying at the same time.* - Participant 6

Others said that they didn't experience any frustration:

> *I felt no frustration, anger, boredom, or stress while using it.* - Participant 2

Frustration was also expressed in relation to time. The participants felt frustrated in the beginning due to lack of understanding and control:

> *I was frustrated in the beginning.* - Participant 1

> *I was a little unsure how things worked in the beginning.* - Participant 4

This seemed to pass quite quickly as they started to explore the installation and learn how to interact with it. This understanding sparked curiosity and engagement to explore more. However, after having explored for a while and not had any new discoveries they grew frustrated and disillusioned:

> *I became frustrated after a while, because I didn't understand the effect of what I was doing. It was rewarding in the beginning, but I was frustrated because I didn't understand.* - Participant 9

Mastery Some of the participants expressed a sense of mastery in relation to control and achievement of goals:

> *You feel mastery after a while and feel that you're in control, and in this context that's very important because if you don't feel that you're in control you grow tired more quickly.* - Participant 1

However, the general consensus was that proper mastery was not really achievable within the limitations of the installation:

> *I had a kind of feeling of mastery in discovering new things, it's connected to goal-achievement, but not in a total sense. It was more fumbling.* - Participant 6

> *[The installation] lacks possibility for mastery.* - Participant 9

> *I don't think I would master it more if I used it for another 20 minutes.* - Participant 3

4.8.3 Context

During our prototype evaluation, the participants made several statements about both how the specific lab-context influenced their experiences, and how they expected to be influenced by other public contexts. Many of them gave unsolicited judgements on how different public contexts would be different from the private lab setting. A recurring theme in our discussion of contexts was the issue of self-consciousness and fear of behaving out of the ordinary. There were also a few comments on how the participants were influenced by being observed and filmed.

Private lab context

Social rules and norms Several of the participants said that they sometimes felt self-conscious, even stupid, when interacting with the installation. This was most prominent in the start of their experience and most of them overcame this feeling quite quickly, due to the private setting of our evaluation.

> *I was a little reserved in the beginning as to how strange movements I made, but in this context it quickly passed.* - Participant 4

> *The thought struck me that we were being filmed and that I was doing many strange things and maybe looked very stupid, but we were in a private setting and I didn't care too much about that.* - Participant 7

Most of the participants commented that they felt at ease in the lab-setting:

> *I didn't feel that there were any [social] rules that were broken during our session.* - Participant 2

> *In this setting we can unfold and explore uninterrupted.* - Participant 6

> *I didn't have any feelings of [self-consciousness] in here, in a closed room, but would definitely feel self-conscious in a more crowded setting.* - Participant 5

Influence from being observed and filmed There were a few comments about the fact that they were being observed and filmed, but these seemed to indicate that this didn't bother them much.

> *We were filmed here, but I didn't give it much thought really. I feel safe that it won't be used outside this context.* - Participant 5

> *It struck me a couple of times that we were being filmed, and the stuff I'm doing looks funny.* - Participant 7

The participant doing the evaluation alone expressed a detrimental effect of being observed and filmed:

> *I would say that this lab setting was destructive for the experience. Especially since you were standing there observing.* - Participant 9

To us, this confirmed that the setup of two participants and two observers worked well, as none of the other participants expressed similar feelings.

Imagined public contexts

Social rules and norms The participants voluntarily underlined that their self-consciousness would become much more important for the experience if it was set in a public context, in the presence of strangers:

> *If we had been [doing this] on the street we would actually be breaking some social conventions. I would feel more restrained by rules and norms on the street.* - Participant 3

> *Even though we were in a closed room I felt that I was doing things that was outside the norm, when it comes to my social conventions. [...] It was positive in that it brings out the child in you, but negative in that you break social conventions by doing things that are not perceived as normal, which might make you restrain yourself when you use it in a public setting.* - Participant 7

Goals One participant mentioned that having a goal or some obvious purpose of the interaction would make it more likely for him to use it in a public context:

> *It's more likely that I would stop and try to achieve a* goal *than to just* play *with it because then it looks like you're actually doing something [purposeful]. I would have forgotten my [social] 'role' if I had an obvious goal.* - Participant 8

Disruption Some participants commented that when they are out in public they usually have a purpose and a destination, making them less inclined to stop to interact with the installation on the street or in a shopping center. However, if the installation was encountered in locations that are destinations themselves, like a museum or gallery, they would be more interested in engaging with it:

> *It would be a lot more socially acceptable in a museum, that you interact with it. I would say my experience would have been much better in a context like that. If the installation were set up in Karl Johan [central shopping street in Oslo] I wouldn't have stopped to check it out, also because I'm going somewhere.* - Participant 9

Flow Flow also came up as a topic in relation to public contexts:

> *If you forget what you were originally doing, then you might be a bit more engaged. And the more you get drawn into it there's a greater chance that you would dare to play with it than if you were aware of your surroundings.* - Participant 7

Although the participant does not explicitly mention *flow*, she describes losing herself in the experience as a way to forget social inhibitions and awkwardness This underlines the need for the installation to immediately spark interest in passers-by and to keep them immersed and preoccupied with the experience.

Subversion A couple of participants touched upon the theme of *subversion* as a positive aspect of behaving out of the ordinary:

> *It can be liberating to break social rules and norms.* - Participant 4

> *It's liberating to break social rules and norms, given that it's rewarded.* - Participant 3

4.8.4 Evaluation sessions assessed by experts

As these evaluation sessions were considered a part of the design process, participants considered experts were asked to comment on both the evaluation process and the PLEX framework specifically. They highlighted both pros and cons of this way of conducting the evaluation.

> *It's great to sit together and discuss, but this also means the probability for the participants influencing each other is large. I think our answers would diverge more if we were to be interviewed separately.* - Participant 1

> *It's very convenient being able to discuss the topics and through this clarify misunderstandings and intentions.* - Participant 2

The experts were overall in agreement that PLEX could be a useful tool to apply to a design process, but some remarks were made about how it should and should not be used.

> *The categories are good.* - Participant 9

> *I see why you want [us] to talk about this, instead of just leaning on this [PLEX survey]. It's easier to discuss this, rather than marking it on a scale. Some of the categories are quite overlapping and are a bit vague.* - Participant 3

> *I missed the time aspect in the PLEX framework, since the experience changes over time.* - Participant 9

> *It's good that you use PLEX in retrospect [after you have created the installation], and not show it to people [potential users] and ask what they wish for. People do not know what they want.* - Participant 9

> *An alternative to the checkboxes for marking level of importance could be to cut out all categories and ask people to sort them in order of importance.* - Participant 9

4.8.5 Quantitative PLEX results

The following graphs are only meant to serve as an overview of the quantitative PLEX results gathered during the interviews. It is important for us to point out that this chart and the organisation of the PLEX scores were made *after* the qualitative data analysis was finished. The scores are based on the responses of nine participants, of which five were defined as experts and four defined as amateurs. Also, to emphasise what was pointed out in the description of the prototype evaluation sessions, we never intended to use the PLEX surveys as a way of collecting statistically valid quantitative data. The evaluation was not designed to be a true experiment or even an experiment at all. Both the participants and we acknowledged the high risk of bias in how these evaluations were conducted, as well as the very small sample size.

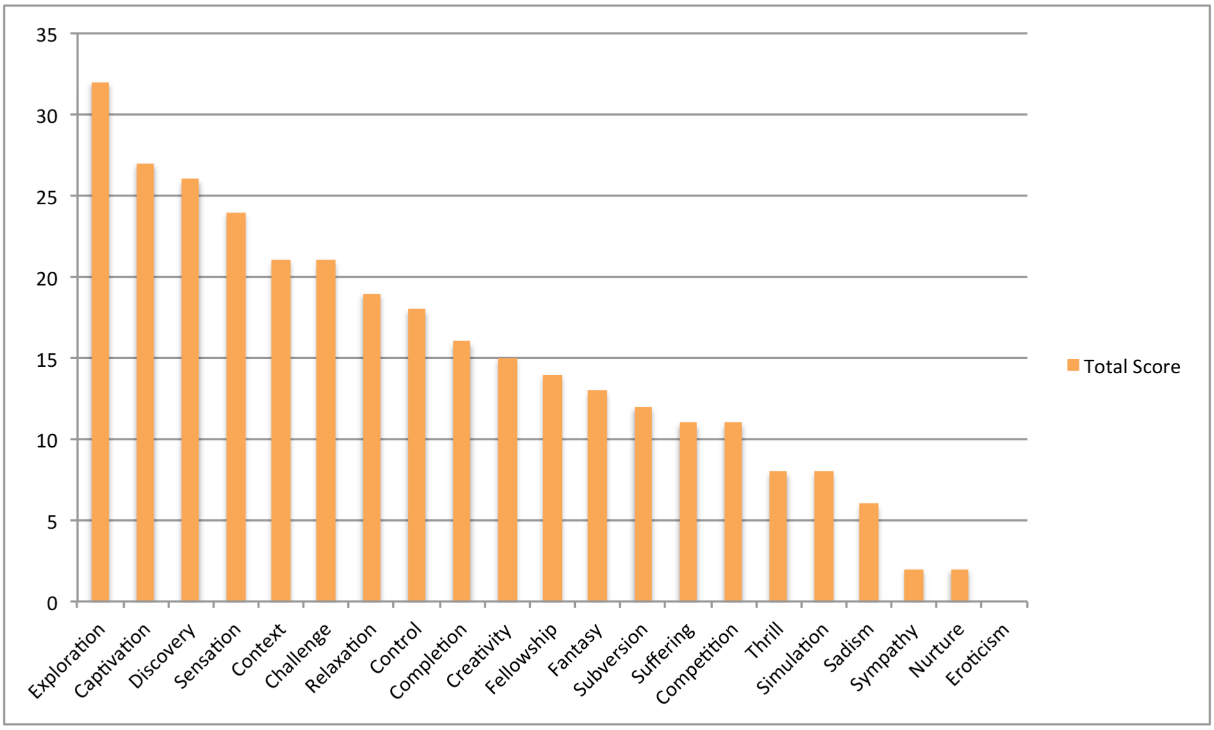

Figure 4.33: PLEX score, sorted descending from left to right, based on score. Max. achievable score is 36 and min. score is zero. Scores are based on the responses of nine participants.

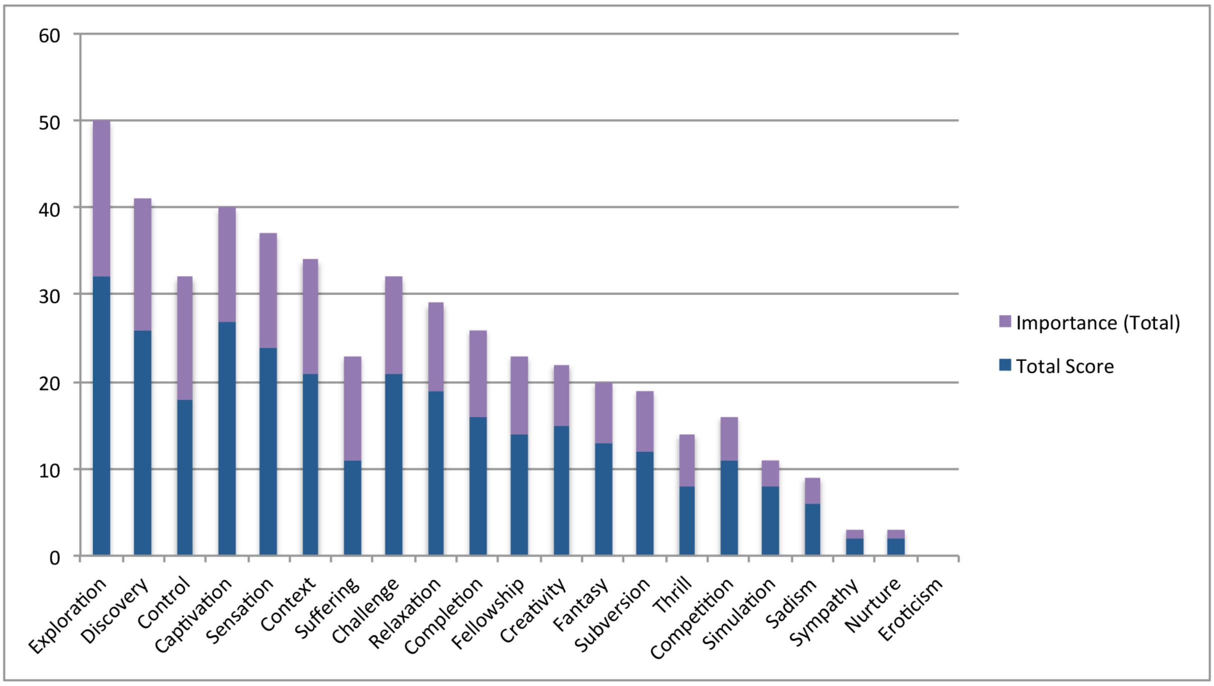

Figure 4.34: PLEX score and importance rating of categories, sorted descending from left to right, based on importance. Max. achievable combined score is 54 (36 for PLEX, 18 for Importance), and min. score is zero. Scores are based on the responses of nine participants.

4.8.6 Changes made to the installation

Modifications were made to both the visual and the audio system in iterations between sessions to continually improve the experience as much as possible. Time available was scarce, so the improvements made had to be prioritised in a strict manner. So even though we were made aware of several important shortcomings, we could only improve the ones that fit into our schedule.

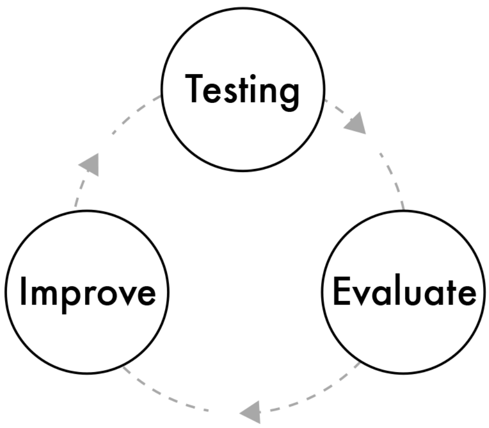

Figure 4.35: The continuous process of iteratively improving the installation with the help of testing it and evaluating needs

The process of iterative improvements during the evaluation sessions went in simplified form something like what is shown in figure 4.35. We *tested* the installation through letting the participants of the evaluation sessions use it, *evaluated* which improvements were feasible to do based on the tests, and went and made the agreed upon *improvements* to the installation, before conducting the next test.

The improvements made during span of the evaluation sessions are the ones described in section 4.5.2, except the 'too close'-zone which was already present. The background colours generated by user positions and the lightning strikes were added as a result of concrete feedback by participants of evaluation session one and two. The slowing down of music when crouching and the gesture based changing of background and interface colours from dark to light and vice versa, were added after evaluation session three.

These improvements were all omnipresent modes, added as easter eggs for users of the installation to discover, hoping to address wishes expressed to have more to explore. Further minor improvements, concerning the wording of- and font sizes of messages displayed in the installation GUI, were added between days of public testing.

Chapter 5

Public tests

5.1 First public test - Science Library

Figure 5.1: Installation spaces at Science Library, University of Oslo. (1) First location. (2) Second location.

5.1.1 Introduction

The first 'real' public test of our installation was at the Science Library at the University of Oslo. The library actively encourages students to develop different kinds of systems and technologies to be used in the library. We were invited to set up our installation on the ground floor of the library building for three consecutive days. This provided a good opportunity for us to observe how people reacted to and interacted with our installation in a 'real' public setting.

Preparing for observation

We were both present for the entire period the installation was displayed, observing and taking notes. In order to ensure that our notes would be comparable, it was important for us to develop a system of codes for registering different kinds of information. We ended up with seven different pieces of information we would record for each 'observation': Nickname or description of person; start- and end- time; if they were alone or in a group; if they actively engaged with the installation or just passively observed; body language; facial expression; and finally, notes. Body language was categorised into: *Shy, curious, engaged, uninhibited, frustrated, self-conscious, indifferent, joyful, and sceptic*. Facial expressions were recorded as emoticons.

Two different locations

The layout of the library building is mirrored around a central stairwell, with two relatively identical, large spaces on either side. There are galleries on the first and second floors, overlooking the spaces.

For the first two days of observations the installation was located between the entrance to the building, the central stairwell and the café in the western wing. This location was probably the most trafficked in the entire building, with people moving between the entrance, the stairwell, adjoining rooms and the café. As such, one would think that it would be well-suited location to set up the installation. However, the screen we used was fixed on the wall opposite the entrance, between the café and the stairwell. This placed our installation in a zone that people mostly passed through on their way into or out of the café, making it difficult for the installation to respond to them before they had passed.

On the third day we moved to the eastern wing where the space was largely empty, with a few tables and some benches along one wall. This was a more quiet and less frequented area where people went to relax or study.

5.1.2 Findings

Duration of observation: 7 hours 49 minutes over three days (2h + 2h 36m + 3h 13m).
Observants: 2
People observed: More than 54 (54 separate observations, including groups).
Active: 35
Passive: 17
Age distribution: Mainly from 17-40 years old, some in their forties, fifties and sixties.
Average time: 1 minute

Overview of numerical data

The next three sections shows the the summed up coded data of the Science Library tests. They are shown as percentages in the charts below, to emphasise the distributions of the findings. The data is not statistically valid and are only included in order to give a general impression of the findings.

Time spent

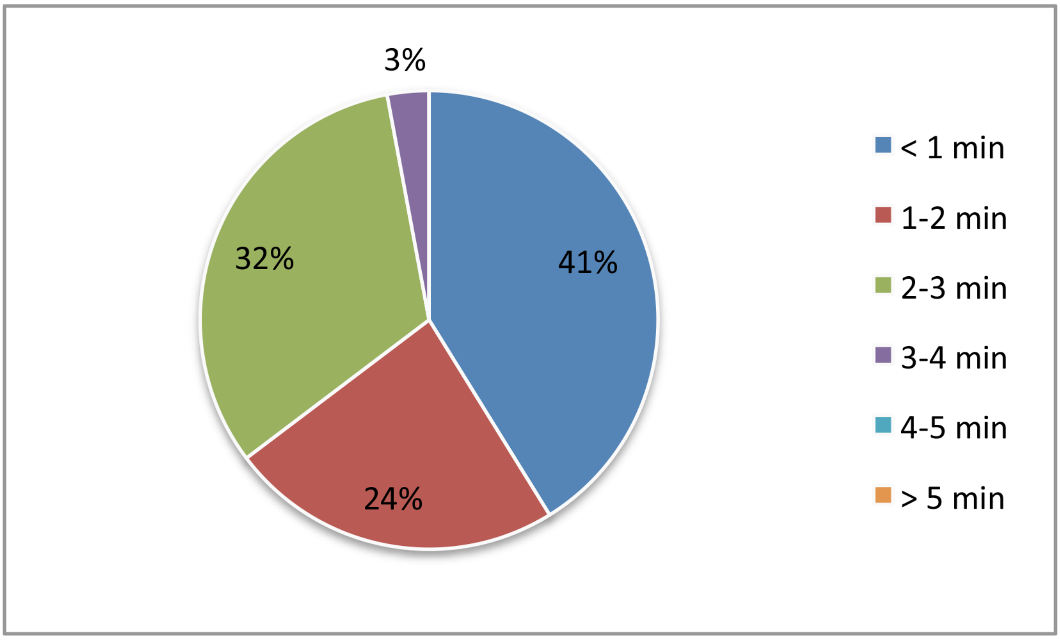

Figure 5.2: Minutes spent interacting with installation by active participants (34).

The granularity of our time-registrations were not fine enough to draw any certain conclusions regarding time spent with the installation, other than that hardly anyone spent more than three minutes. However, when comparing *time spent* to whether the person was alone or in a group, we saw that people who were in a group spent twice as long (1.2 minutes), on average, as a person who interacted with the installation alone (0.5 minute).

Body language

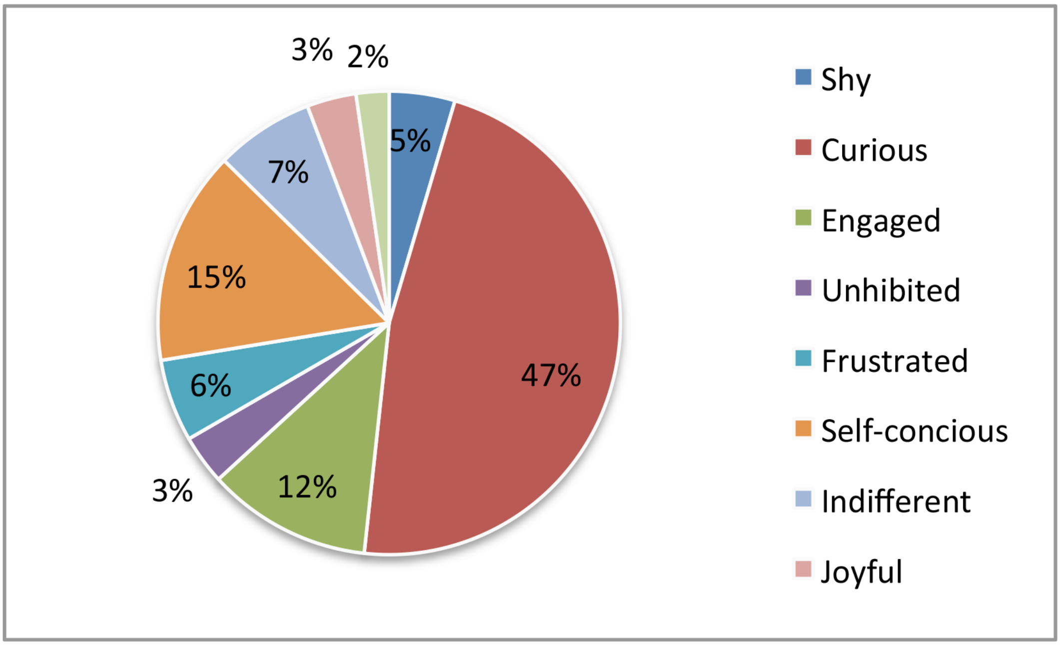

Figure 5.3: Distribution of body language of all observed (87), according to coding scheme. Most participants seem to display curiosity towards the installation.

Recording of more than one type of body language per observation was allowed.

Facial expressions

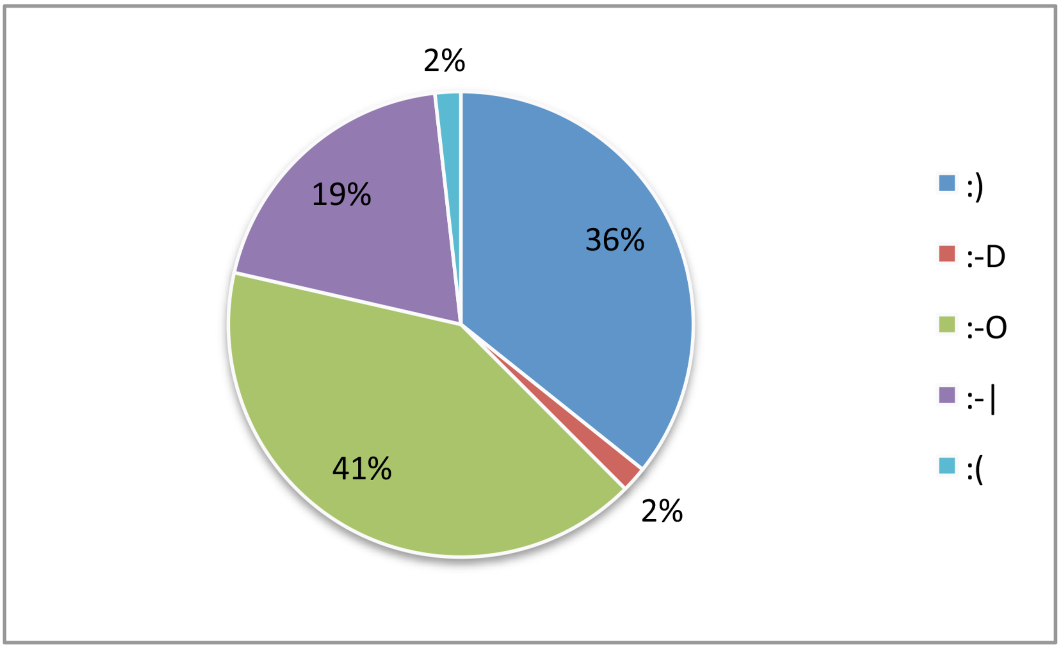

Figure 5.4: Distribution of facial expressions of all observed (56), according to coding scheme.

Recording of more than one facial expression per observation was allowed. Our emoticon coding scheme for facial expressions is to be understood in the following manner:
:-D - laughing
:-) - smiling
:-O - fascinated
:-| - neutral or indifferent
:-(- negative, as in angry, sad, frustrated or annoyed

Passive onlookers

Throughout the three days of observations we noticed that many people were reluctant to engage with the installation when it reacted to their presence as they walked by. They seemed confused and startled by the sudden appearance of music and strange visuals appearing on-screen. However, people sitting at the tables or otherwise hanging around would divert their attention to the installation when other people engaged with it.

> *Stands still and observes 'friend of man eating a banana'. Does not try himself. Had clearly seen the installation from the café area.* - Man eating a banana (Curious and indifferent, 1 minute, :-O)

As we were sitting on a café-table beside the installation we had a good view of the surrounding space and the people occupying it. Also, the installation was in a position of the ground floor which made it visible from galleries on the first and second floors where students were studying. The intermittent appearance of music and sound would grab people's attention, both on the ground floor and on the first and second floor galleries.

> *Two other girls pass them in the other direction. The other girls trigger sound and graphics. These girls stop in the stairs, looking at the screen. Exclaims 'oooOOOooo!' and promptly moves on when discovering that movement triggers interaction* - Girl trio (Curious and self-conscious, >1 minute, :-O :))

When use is demonstrated At one point during day two, our thesis supervisor stopped by with a colleague. She was of course familiar with how the installation worked. They interacted on and off with the installation for a while, talking amongst themselves while testing and showing off the functionality. During this period, the installation gained considerable attention from onlookers compared to when inexperienced participants were interacting. At one point the crowd gathered counted upwards of 20 people.

> *Thesis supervisor and colleague use the installation. People are peering a lot more, stopping in the stairs and at the edges of where the installation is placed. Lots of curiosity. Some are shy.* - (19 minutes)

Self-consciousness overcome by curiosity

A girl was sitting with some friends at one of the tables in the café, watching people trigger and interact with the installation. At one point she stood up and walked over to the installation. She waved her hand, got a response from the installation, said *"OK"*, and promptly returned to her friends. She seemed to be conflicted between a curiosity about the installation and the idea of interacting with it in such an open and populated setting. Similar occurrences were observed a total of eleven times among active participants coded as self-conscious. Always with the outcome of the participant giving up, or giving in to the apparent awkwardness of the situation, either before being detected by the installation or before 'getting it'.

> *Walks in and out a couple of times, waves to the installation. Gets really shy the first time. Is not detected by installation the second time. Gets very shy and leaves.* - Grey jacket girl (Self-conscious, curious and frustrated, >1 minute, :))

Learning from others

People soon learned that whenever the music started, there were people interacting with the installation. This allowed them to look up whenever the installation was in use, thereby slowly building an understanding of how it worked. This also allowed them to build both curiosity and courage to try the installation themselves. We saw several examples of people coming up to investigate after having observed others interacting with it for a while.

saw screen from upstairs, went downstairs, someone else triggered inst. he noticed and stopped and looked baffled, continued down the stairs, came back and started investigating, interacted for a little while, and left - boy from second floor (Curious, 2 minutes, :-O)

There were also examples of single persons and groups of people who were hanging around in the background, queuing when others were interacting with the installation. As soon as the people using the installation left, they would walk up and have a go at it. It was clear that watching others interact with the installation made people want to try it for themselves. This worked like a positive feedback loop, where use attracted attention and instigated more use.

Stands waiting for 'oilskin man' and friends. Observes and smiles. When 'oilskin man' with friends leave, they move straight to the installation and start exploring. Learning from previous group. Acting out and waving their hands, finds several modes. - Group of four friends (Engaged and curious, 2 minutes, :) :-O)

However, the installation was unable to keep people's interest for more than a minute or two, which meant that there would have to be a constant stream of people to keep the installation in continuous use. When the installation was allowed to go into standby mode, people quickly returned their attention to whatever they were otherwise doing.

Cooperation

In terms of level of engagement, those people who explored the installation together with others seemed to get more out of it than those that were alone. They would talk to each other and explore cooperatively, discovering more functionality than those that were alone. But, despite getting quite engaged and involved, they would still not spend more than a maximum of 2-3 minutes before moving on.

wanted to try but scared to do it alone, wanted friend to participate so she wouldn't be alone, they both went over and tried but girl was ID as user 5 on sound system and did not get audio feedback, left shortly after - Blonde girl and friend (Curious and shy, 2 minutes, :-|)

one or two of them had seen others interacting with it and invited the others to join him in testing it, waved arms and got response, they were in different zones and triggered different effects, commented to each other on what was happening, thought it was cool, left after a little exploration - Group of three boys (Curious, 2 minutes, :) :-O)

Returning with friends

There were also a several examples where people we had observed interacting with the installation earlier came back with friends. They would show and explain how they thought the installation worked, and they would try interacting with it together.

Waves arms around, twirling. Confused, tries gesticulating in particle mode. Returns later with friends. Large spastic movements. - Green sweater man (Curious, engaged and uninhibited, 2 minutes, :))

Incidents also occurred of persons, who earlier had been noted as passive observers, came back with friends and took active part in the installation together.

Stands in the background by door and observes. Talks female friend into the installation. Does not try himself. Stands still by female friend. Returns later with male friend. Shows and explains. Friend of insecure girl - (Curious, >1 minute, :))

A curious detail about this observation is that 'Friend of insecure girl' makes his friend participate instead of himself.

Quotes

Some people made comments and statements about the installation. We include a few quotes of statements people made as an illustration of the kind of reactions people had. There were short and immediate reactions like:

Awesome! Motion sensor, cool! - Backpack man (Curious and engaged, 2 minutes, :))

Shit! Wow! - Carhartt girl (Self-conscious, curious and engaged, >1 minutes, :-O :))

Very cool! Friend of oilskin - (Curious and engaged, 3 minutes, :-O :))

Pretty cool! - Camo pupil (Curious, 2 minutes, :-O)

There were also more reflective statements and questions:

Is this some kind of project? - Coffee man (Curious, engaged and uninhibited, >1 minutes, :))

It responds to my movement. - Hat man (Curious, >1, :))

After exploring for a minute, one man, of about 60 years old, exclaimed:

One could stand here all day, fooling around! - Older man (Joyful and curious , 2 minutes, :-O :))

One woman came to meet a few people waiting for her at a table in the café. As she walked in she saw some others interacting with the installation and exclaimed to her friends as she sat down:

There's something new happening here all the time!

This could possibly indicate that the people frequenting the building on a regular basis are used to strange and different things happening. If this is the case, it relates well to the expressed vision of the Science Library staff on how the library should be used. Their intention are that the Science Library should be a living, open, vibrant place with frequent events and headroom for discussion and conversation in the common areas, in contrast to a traditional 'silent' library. This might be one of the reasons for the amount of attention an installation of this kind gets in the library, considering it can at times be quite noisy when in use. During our three days of exhibiting, we received no noise complaints at all. This could indicate that the frequent users of the library are used to this kind of ruckus.

Limitations and errors beyond our control

There were different bugs and shortcomings with our installation, which at times made it work less than optimal when people tried to interact with it.

Speed of auto-detection Our two systems normally detected people quite easily within 1-2 seconds when they entered its field of view. However, when people were moving at normal walking speed and didn't stop to allow the Kinect to get a clear reading, it took slightly longer for them to be detected, maybe 2-4 seconds. This problem was exacerbated on the first location by large windows opposite the Kinects. In our technological exploration, we found that direct sunlight and glass are detrimental to the precision of the Kinects by disturbing the IR-signal (Section 4.2.1). This seemed to make the Kinects use even longer to detect people. We did not do any timed tests and do not have more than our own observations to go on, but we noticed a marked lag in time before people were detected compared to our lab tests. Also, due to the cone-shaped field of view, people passing through it close to the Kinect would only spend about a second or two inside the active area, thereby not giving the Kinects enough time to identify them. We could see on our computers that the Kinects were trying to register people and assign them user IDs, but could not get a good enough reading before people had passed. The sum result was that many people passed through the field of view without triggering the installation at all, particularly on the first location by the café and entrance to the building.

On the third day we moved to a more secluded spot on the opposite side of the building's central stairwell. The spot was almost identical to the previous one, but with a white wall instead of windows on the opposite side. The lighting conditions were therefore considerably more suited for the Kinect sensors, making a noticeable improvement in how fast people were detected. Contrary to the first location, this spot was not a space where people were passing through, but somewhere they would go to sit down and study. This area also included the building's main elevator, and the zone where people were waiting for elevator was in the outskirts of the installation's field of view. This resulted in the system detecting people waiting for- and coming out of the elevator and then pulling people into the installation, instead of trying to 'assault' them while on the move.

Number of users As already mentioned in section 4.6.1, our two subsystems had no way of uniformly registering users with the same ID, making it impossible to ensure that they registered people in a uniform way. Also, while the visual system could track at least six people simultaneously, the audio system could only track a maximum of four people. This was unproblematic as long as there were four or less people interacting with it at the same time, but when there were more than four people in the installation's field of view, some people did not get any audio-feedback on their movements. However, due to the sustained and layered way the sounds were set up it became increasingly difficult to separate the sounds produced by different people as the number of participants increased. With four other people producing a cacophony of sound, it was hardly noticeable for the fifth or more person that they were not producing any sound. As long as they got a visual response on the screen, they didn't seem too bothered.

This was fine as long as everyone in the field of view were interacting with installation. But when people were standing inside the field of view, either watching others interacting, or just talking to some friends and ignoring the installation, they would still be registered by either one or both of our subsystems, thereby tying up user IDs. The result was that people trying to interact with the installation didn't get any response because all user ID's were taken by people who were not actively engaging with it. This was a serious issue as a lack of response from the system made people lose interest very fast.

Due to the user-registration issues described above, we had to constantly monitor the user ID numbers in the audio system to see which user IDs were used. Whenever user IDs #1 through #4 were held by people not interacting with the installation, the communication with the driver was reset manually by us in order to free up the first four user IDs. This killed the sound produced by other participants, as well as the music. However, the restart usually took five to ten seconds, and since the visual system was not affected, participants were sometimes too preoccupied with the visuals to notice that the sound disappeared for a short while.

These discoveries made it apparent that the limitations of the technology dictates the setting and placement the installation is suitable for, at least to a certain degree. In our experience the ideal setting would be a place with a certain degree of seclusion. It would not work well placed in settings that involves crowds, because of the issues of 'inactive users' and the maximum number of users that can be tracked. Our intention of having the installation work as a tripwire system might work if it was placed somewhere that is a natural destination for people, but not in heavily trafficked areas where people are mostly passing through, like the foyer entrance of the Library, because of the time it takes for the system to identify people.

Limitations and errors within our control

Human error During our second day of observations we needed to do some small adjustments to the setup, requiring us to turn off the speakers. When we started the system again, we forgot to turn the speakers back on. We sat for the next half hour watching people passing through the installations field of view without noticing it at all. At first we just thought they were just moving too quickly to allow the system to register them, as was often the case. However, after a while we noticed that even though people were standing in the field of view the music didn't start, nor were there any other sounds in response to people's movements. After some investigation, we discovered the problem and turned the speakers back on.

This made us realise that the audio feedback was central to attract attention from people and to make them aware of the installation. During the period the speakers had been turned off, not a single person had taken notice of the installation at all, even though the visual system was working fine. It also made it apparent that the visual system did not pull its weight in terms of creating attention and pulling people into the installation. It was simply not nearly eye catching enough in standby mode, especially on a smaller screen like a TV as was the case at the library. It might have worked better with a projector and canvas setup, but we still think it needed more attention grabbing elements like less subtle animations or even textual messages to demand attention.

Memory leaks in visual system Due to an apparent memory leak in the visual system, restarts were required after a period of heavy interaction with the system by two or more people. The cause of this was most likely the particle systems and the physics engine running them. Intensive interaction by several people required a considerable amount of calculations on a lot of data to be done for each frame tick (Section 4.6.2), and some of this data might have remained in memory, clogging up the system. This had the effect that the frame rate of the visual became very low and created a disconnect between behaviour the audio and the visual system, making it less responsive. This issue is at least partly caused by sloppy programming due to time constraints in the development process, and could have been addressed by optimising and rewriting code. If the aim were to create a finished product, this would have had to be fixed, but since our installation was only a high fidelity prototype, we did not consider fixing it part of our scope.

5.2 Second public test - Oslo Mini Maker Faire

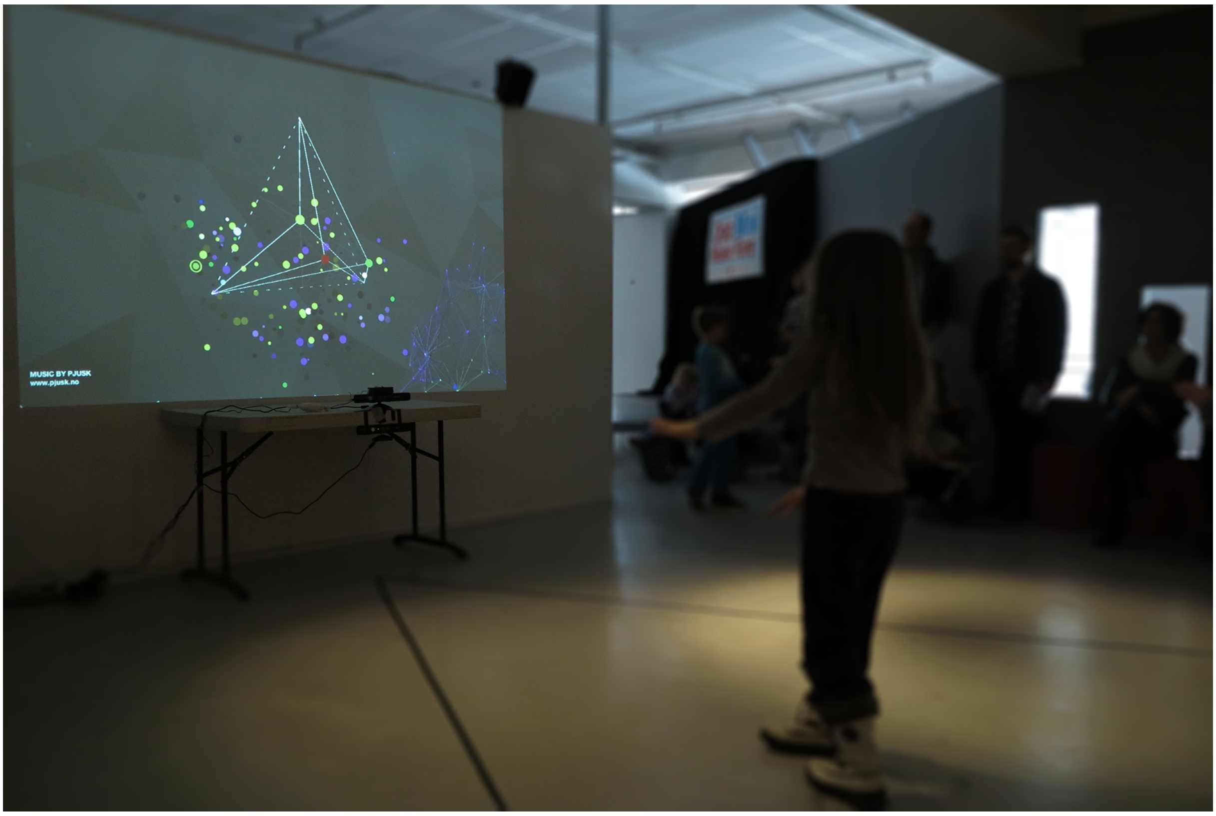

Figure 5.5: Installation space at Oslo Mini Maker Faire, Norsk Teknisk Museum

5.2.1 Introduction

The first ever Mini Maker Faire in Oslo was held at Norsk Teknisk Museum (The Norwegian Science Museum) on April 6th and 7th, 2013. The Maker Faire is *"a family-friendly festival of invention, creativity and resourcefulness, and a celebration of the Maker movement"* [61]. We applied to take part with our installation and were accepted. This gave us the opportunity to display our installation in the setting we originally envisioned it to be best suitable for, as described in our intentions (Section 4.1). The Museum is a destination in its own right and its visitors are there to see, learn and experience by actively partaking. We therefore expected its visitors to be more open to new experiences than people were at the University Science Library, where students, staff, and guests went about their daily business.

Observation and note-taking

Participation at the Maker Faire required us to interact with the visitors, to answer their questions, and demonstrate how our installation worked. It was therefore impossible for us to anonymously observe and take notes in the same way we had done at the Science Library. We therefore enlisted the help of our thesis supervisor to come by and observe and take notes for a while. She also brought a friend who was an expert of sensory perception. They used the same coding system that was used at the Science Library.

5.2.2 Findings

Duration of observation: 42 minutes, one day.
Observants: 2
People observed: 33
Age distribution: From about one year old to somewhere in the sixties.
Average time: Over 2 minutes.

Overview of numerical data

Like in section 5.1.2, the following sections, 'Time spent', 'Body language' and 'Facial expressions', shows the distribution of the quantifiable observations done at the Oslo Mini Maker Faire. These data sets are also not statistically valid, because of the low sample size and the short time spent observing. Still, we argue that the behaviour seen in the window of observation was representative to the rest of the day, and may still give an indication to how the installation was perceived by the museum visitors.

Time spent

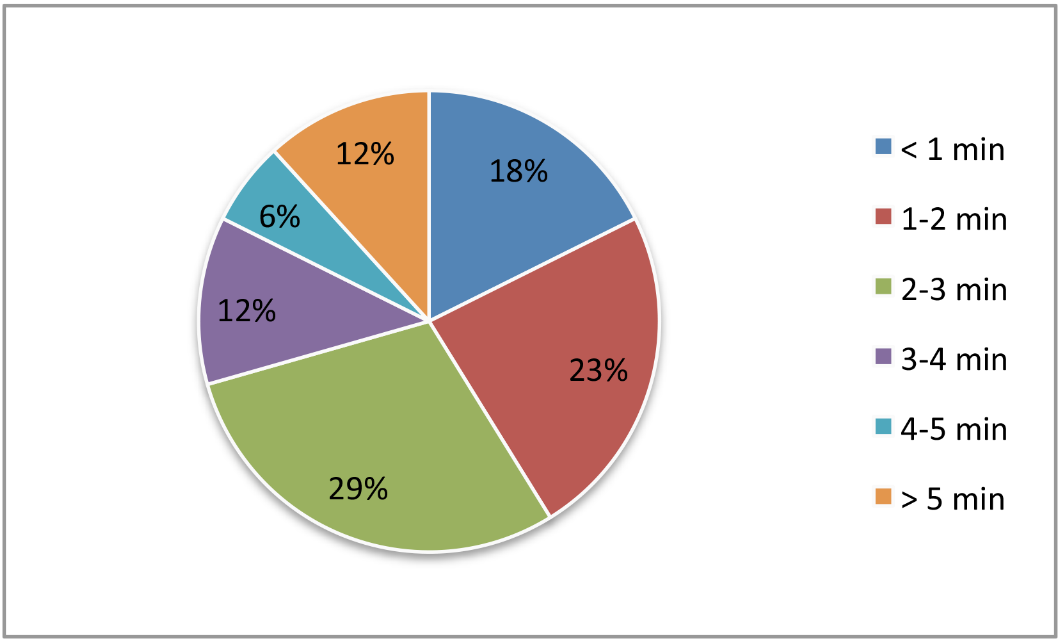

Figure 5.6: Time spent interacting with installation by active participants (17).

Body language

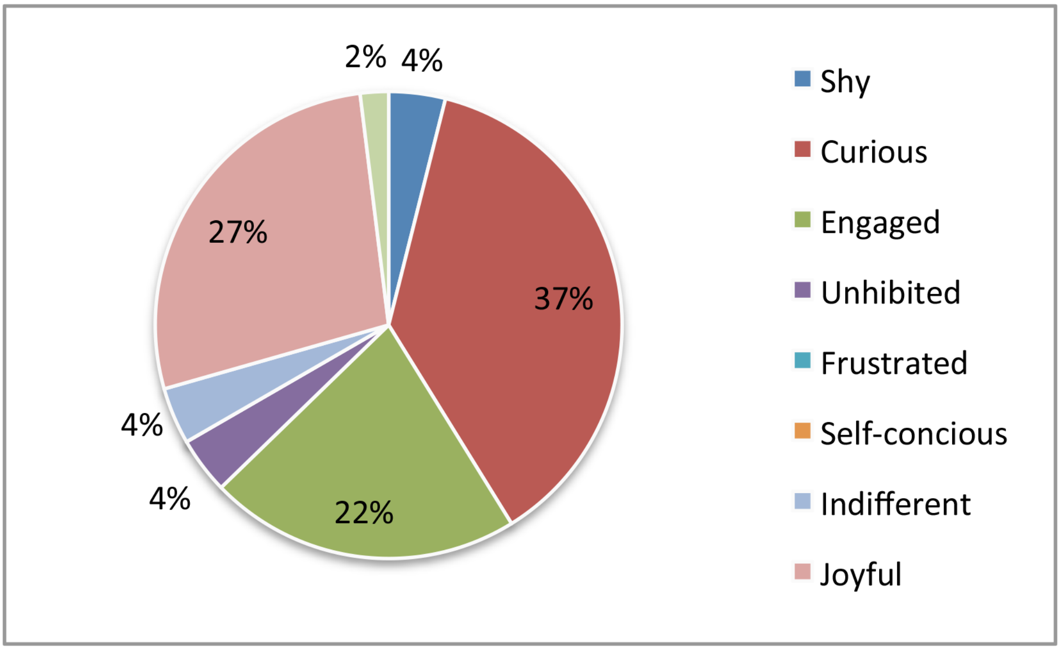

Figure 5.7: Distribution of body language of all observations (51), according to coding scheme.

There was one instance of self-consciousness recorded in the observation notes, but this has been removed from the data basis, since it was used to describe body language in the meaning of expressing complete body control and awareness of movement like a dancer, in contrast to the way self-consciousness was recorded during the Science Library observations, as an expression of insecurity and shyness. Recording of more than one type of body language per observation was allowed.

Facial expressions

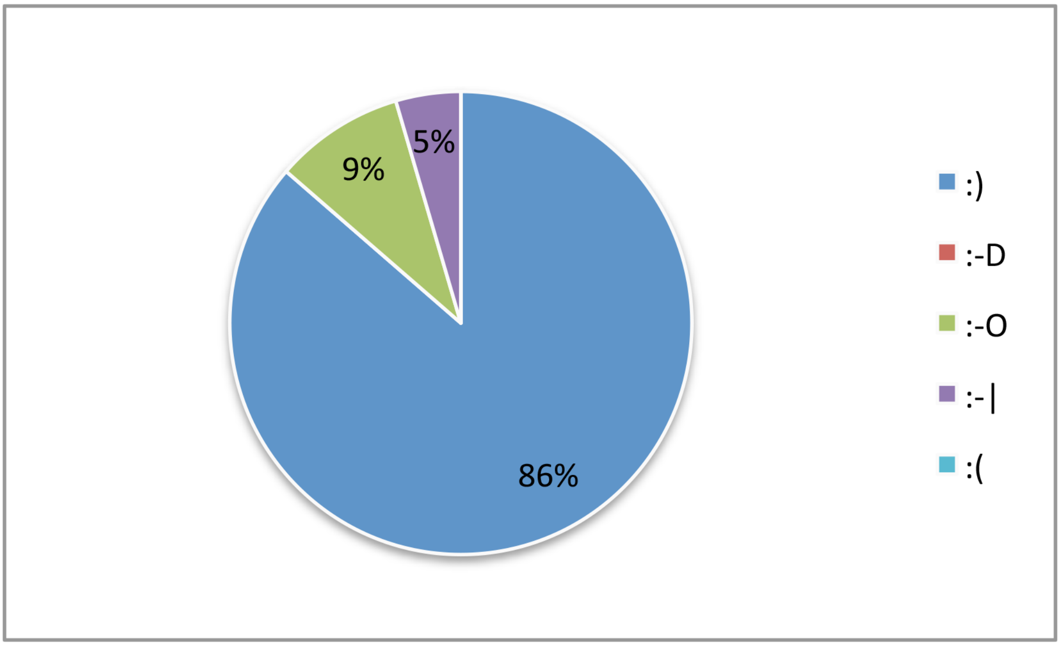

Figure 5.8: Distribution of facial expressions of all observations (22), according to coding scheme.

In the Maker Faire observation notes, words were used to describe facial expressions. These were later converted to our emoticon coding scheme as used in the Science Library observations (Section 5.1.2). Recording of more than one facial expression per observation was allowed. They are to be understood in the following manner:
:-D - laughing
:-) - smiling
:-O - fascinated
:-| - neutral or indifferent
:-(- negative, as in angry, sad, frustrated or annoyed

From the notes that were taken, 19 out of 22 people were registered as smiling, 2 looked fascinated, with mouths open, and one looked indifferent. In addition to the notes, most of the people we observed interacting with the installation throughout the day had expressions of joy, laughter, curiosity, fascination, and amazement. Some of the younger children seemed shy, intimidated and confused by what was going on at first, but would loosen up after being guided and helped by siblings or parents.

> *A man and a baby come in and try. The baby is totally fascinated by colours and graphics.*
>
> *Two girls, looking like students (early 20) smile broadly.*
>
> *A boy comes in. He is obviously fascinated by colours and graphics.*

A grandmother tries. She has 2 grandchildren. She is about 60, and the kids are young. They all smile. The grandfather comes in for a moment. They all leave. (2 min)

Passive onlookers

There were no specific observations made of onlookers at the Maker Faire, but as this was an event setting, we took special precautions to keep passive onlookers out of the way of the people wanting to partake in the experience.

The space we were assigned at the Mini Maker Faire formed a capital 'D' when seen from above, with open entrances at either end of the straight line/wall. The dimensions of this space were very beneficial to our installation. The installation was set up in the middle of the straight wall, facing the opposite curved wall. This left some space along the curved wall on either side of the installation's field of view. One of the lessons learned from the test sessions at the University library was that passive onlookers who were standing in the field of view would tie up user IDs in the system, making them unavailable for people who tried to actively interact with the installation. By strategically positioning small chairs along the curved wall on either side of the field of view, we hoped to reduce interference from bystanders by providing a place for them to sit. We also visually outlined the field of view with tape on the floor, making it easier for people to understand the boundaries of the installation. This worked remarkably well. Families with children and strollers would enter, and some of them would sit down on the chairs while the others tried the installation. They were still able to communicate and discuss the experiences.

Persuading others to try installation Related to the peculiar behaviour also seen at the Science Library (Section 5.1.2), we observed at least two fathers not willing to partake in the installation, but obviously interested, pushing their hesitant children into the tape marked field of view of the installation while saying 'You try it!'.

Returning visitors

There were several people who returned to the installation after having tried it earlier. They would bring back friends or relatives, and show and explain how things worked. Or they would come back alone, after having been there with others earlier. There was one girl (about 10 years old) in particular who seemed to really enjoy the experience. She came back several times, and in total spent upwards of 45 minutes using the installation, becoming quite the expert user. When others expressed confusion about what was happening, she explained how it worked and showed them how to use it. Her mother spent long periods sitting on a chair on the side, patiently waiting. She also left and came back a few times while her daughter was preoccupied with the installation.

Cooperation and learning from others

There were many examples of people cooperatively exploring the installation. They assisted each other and explained to each other what they had discovered. Onlookers would learn by watching others, and subsequently step up without hesitation to try for themselves when the installation space became available.

> *Mother explains to the boy relation between graphics and his movements, music and his movements. The boy is very satisfied. The girl is shy. The boy really explores. Comes too close to Kinect and slowly backs up, making huge movements.*

> *Two boys join in, one young, ca 4-5, the other bigger. The bigger boy explores freely, big movements. The small one mimics after the other one.*

> *Two girls, looking like students (early 20) smile broadly. Nearly dance in the Kinect vision field. They try also to cooperate a bit, they communicate what they want, try all positions within triangle of vision, move up and down, even jump. (2 min).*

This was also the only time we observed people trying and succeeding in creating a coherent visual expression through cooperation.

> *A young man and a girl in 20ies try. [...] They continue. Cooperate. They seem to have fun. The graphics are very nice (same style of course, but mixture much richer). Both are smiling and clearly enjoying the experience. (5 minutes)*

Body movement

The installation provoked a large range of different movements as people tried to make sense of it. From the shy and confused gestures of small children when first seeing the installation, to expansive and expressive movements like swirls, kicks, and jumps that went way beyond what the installation provided for.

> *A boy ca 5 interacting with the system, big movement with his hands, smiling, seems really engaged. (5 minutes)*

> *A girl and a boy, ca aged 10 try. They are really researching the field, the girl is dancing, almost breakdance style, very uninhibited (3 min)*

> *A mother and a daughter ca 3 years of age try carefully. Perhaps shy. The boy comes back- he is the brother of the little girl. Mother explains to the boy relation between graphics and his movements, music and his movements. The boy is very satisfied. The girl is shy. The boy really explores. Comes too close to Kinect and slowly backs up, making huge movements.*

Quotes

> *A boy aged 4-5 comes in. After a few seconds he is alone. Really curious, smiling. As he leaves, he says 'This was fun.*
>
> *The mother says aloud: This was really fun! (3 min)*
>
> *A lady in 20ies tries. Smiles and says Cool. Talks aloud. 'Do I influence the music? Oh yes, I see' Tries carefully. Says 'cool' again and leaves. (1min)*

System fails and errors

We had to contend with the same issues of user identification in the audio system and memory leaks in the visual code that we experienced at the Science Library (Section 5.1.2). Additionally, the system crashed once:

> *A young man and a girl in 20ies try. The system breaks down. Wait for it to reboot. They seem not to mind and continue exploring with big smiles on their faces. System breaks down again, reboot again- takes just some seconds. They continue...*

Chapter 6

Discussion

6.1 RQ 1: How to design and evaluate an interactive installation that facilitates for enjoyable user experiences?

6.1.1 Design process

This thesis has been an interpretive, design-based exploration into enjoyable user experiences. As such, the design process is an integral part of our findings. We will in the following section discuss our design process in relation to our intention of creating an enjoyable, open-ended experience (Section 4.1). We will also discuss our prototype evaluation methods, as well as findings from our evaluation sessions.

Exploration of technology and prototypes

The design process started with an exploration and familiarisation with the technologies available, in order to get an understanding of the possibilities and limitations these presented for our design. By building different simple prototypes we were able to learn both how the technologies worked, and how this knowledge could be applied to our final design.

Division of tasks Quite early in this explorative process, we made the choice of dividing our respective responsibilities according to our previous knowledge and expertise. One of us would be responsible for the visual part of the installation, while the other would be responsible for the audio. At the time, we felt that this division of tasks would enable both of us to explore the appropriate technologies for our respective parts, and at the same time allow us to draw on our previous knowledge. This decision proved to be defining for how the subsequent design process would evolve, as well as how the final installation would work.

Regarding our intentions, the division of responsibilities worked quite well. We were both able to focus on the particularities of our different needs. We were also able to test the different prototypes we developed on each other and provide valuable feedback, and build a common understanding of what would be possible to build and enjoyable to use. However, as we have shown in the design process (Section 4), the division of responsibilities eventually led us to develop two independent systems. This was not a clear intention when we divided our responsibilities, and presented us with a few issues and challenges regarding the setup of the final installation.

Having two separate systems meant that we would have to align all functionality between the systems in order for them to work and appear as a single installation for the user. This was solved by agreeing on a common grid-structure for the user-interaction that could be assigned different functionalities, thereby allowing us to iteratively test and align functionalities between the two systems. The grid structure worked quite well, but there were a few small discrepancies regarding the borders of our three user-zones. If a person was standing on the border, the sound from the front zone would be played, while the visuals of the rear zone would appear on-screen. However this discrepancy did not seem to bother people much while interacting with the installation, probably due to the abstract nature of the sound and visuals.

Interference A slightly more serious issue was that the use of two Kinects introduced interference issues with the IR sensors, making the tracking data less stable and reliable (Section 4.2.9). We ran a few tests where we could see the interference appear as black holes in the depth-maps coming from the Kinects. The solution of introducing vibrations to one of the Kinects severely reduced the interference to within tolerable levels (Section 4.2.9). It would clearly be better to have both systems respond to the same data coming from a single Kinect, but given the alternative of having to run everything from a single computer, we were satisfied with our chosen solution.

User identification The most serious issue with building two systems instead of one was the user-identification issues described in section 4.6.1. This was was a problem we never considered when making the decision to build two separate systems, because at the time the OpenNI driver was not able to automatically detect users without them doing an initialising pose. We were too far into the process to reconsider our choices when the driver was updated with the auto-detect feature. It is also quite possible that we still would have chosen to divide our responsibilities in the same way if we had been aware of this at the start, but we would probably have given it more attention earlier in the design process. As it turned out, this was an issue beyond our control and something we just had to cope with by constantly monitoring user IDs and restarting the audio system when too many IDs were in use.

The visual system Everything considered, we ended up being quite happy with the choice of using the combination of Processing and Java to develop the visual system, although this choice still has its drawbacks. One notable drawback is its limitations in performance, but especially prominent is the fact that Processing makes it quite simple to do certain things, but considerably harder to do others, as described in section 4.2.4. This fact that Processing makes it simple to achieve certain things is both a blessing and a curse, as it also means advanced mechanisms are simplified to be out of control of the developer and this makes it harder to optimise, modify and debug Processing specific code. These obstacles can result in difficulties like the ones described in section 5.1.2.

This means if we should chose to expand the installation as it is today or do it over again, knowing what we know today, we most certainly would rewrite the visual system, using C++ as a programming language and either openFrameworks or Cinder as frameworks for working with visuals and Kinect-data.

The sound system The choice of using Max/MSP in combination with MIDI and Logic Audio worked quite well. It allowed us to explore a variety of sounds quite easily, without having to modify the Max-patch that specified how the system responded to users' movements. It also provided us with powerful sound-design tools that could be controlled from the Max-patch (through MIDI), making it possible to assign tracking data from the Kinect to control parameters affecting the sound. However, the MIDI-protocol is 30 years old, and there are limitations to what can be done with it in terms of speed and granularity. If we were to build the installation again from scratch, knowing what we have learned through this process, we would try to build the sound-playback directly into the Max-patch instead of relying on MIDI and Logic Studio.

The sound system was able to automatically detect and track up to four users. However, due to the discrepancy between the OpenNI driver and the *Kinect-Via-OSCeleton* Max-patch, the audio system had problems identifying and registering users when there were many people in its field of view. This was a problem beyond our control and something we just had to deal with by quickly restarting our system when problems occurred.

Exploration of prototypes The development of different prototypes was done in parallel with the technological exploration. As we gained an understanding of how the technologies could be used, we tried to apply this knowledge by building simple prototypes. When we ran into problems building the prototypes we went back to researching the technology in order to solve our specific problems. In this way we iteratively switched between building specific prototypes and researching how the technology could be applied to achieve the desired functionality. When our prototypes worked well enough, we tested them on each other as well as on friends, and discussed how they could be improved or combined with other functionality. This gave us a quick way to assess the viability of different ideas without having to build more complete systems. By the end of the exploration-period, we felt we had a reasonable grip on what we would be able to build, evaluate and publicly display within the remaining four months. Our process of creating a series of prototypes resembles the process of inventing toys, as described by toymaker Brendan Boyle when interviewed by Bill Moggridge, see [22, p.341]:

> *We do a lot of proof-of-concept models that we won't show to anybody; we're just trying them out ourselves to see if an idea has merit. We set up*

brainstorms on a regular basis, and we also try to get out to the toy stores once a week just to see stuff that's happening.

Brendan Boyle also emphasises the importance of seeking inspiration to spark ideas, which was an integral part of our process of designing the installation. We find this comparison to a toy inventing process quite fitting, since if we should attempt to categorise our installation we might as well label it as a toy.

Research approach

Qualitative vs quantitative It is our experience that both qualitative and quantitative data are useful for understanding and exploring user experiences. Most of our generated data has been qualitative, and we have had a qualitative focus throughout our research. This has made it possible for us to reach a level of understanding of the participants' experiences that would not have been possible through strictly quantitative approaches. Nevertheless, it was surprising to see how well the highest scoring PLEX categories (see Appendix B) corroborated with our findings from the qualitative analysis. *Exploration*, *discovery*, *control*, *captivation*, *sensation*, and *context* received high importance-scores (27 to 22 points), meaning that the participants deemed these categories important for the overall experience. Ranked by the scores indicating to what degree the participants experienced a certain category, the top five categories were *exploration*, *captivation*, *discovery*, *sensation*, and *context* (41 to 30 points). The most notable difference between the two sets is the category of control. The scores indicate that the participants agreed that control was important to their experiences, but that they did not experience enough control. It was also interesting to see that the *context* category, which was the only category we added to the list of PLEX categories, received relatively high scores.

From our qualitative analysis we had found that *exploration*, *aesthetics* (often associated with sensation) and *flow* (linked to the term captivation) are perceived as successful aspects of the installation and the experience, and the biggest failure is the lack of control. However, discovery (linked to both understanding, discovering and learning) was a debated topic. Participants did not agree on its definition, how important it was for the experience and whether the degree of discovery was positive or negative. From the PLEX scores, we could be led to believe that the participants had a great sense of discovery, but our qualitative data was clearly more ambiguous about the participants' sense of discovery and learning. This was also the case with *suffering*. Some participants scored the amount of suffering they experienced quite low, but rated suffering to be very important, meaning it was very important that suffering was absent from the experience. Others gave the experience of suffering the same low score, but rated its importance high on the grounds of suffering being a part of the challenge aspect. These differing reasons and explanations of the scores would have been impossible for us to pick up through a survey or other quantitative methods.

We also recorded different kinds of quantitative data during our public observations. Data like facial expressions, body language and time was coded in quantifiable ways and clearly showed marked differences between the two public settings. Our collection of data was too small to have any statistical validity, but it still gave some general indications into how participants experienced the installation and its given context. It was particularly interesting to see how the data differed between the two public contexts.

Grounded theory The process of coding and categorising our data was both enlightening and frustrating. By constantly reviewing the data we became quite intimately familiar with it, and were able to identify several main themes. But we could also see how interconnected the different themes and categories were, and as we got further into the coding process it became increasingly difficult to organise our data into very distinct categories. Qualitative data does not fit neatly into categories, and a single statement can have implications for many categories. In spite of this, we feel that the process of constantly reviewing and re-coding our data provided a good insight into the material, and gave us confidence in our findings.

Evaluation methods

During our three main tests of the installation, the main data gathering methods used were *observation* and *interviews*.

Observation Observing people was very useful for us in evaluating and understanding the experiences people had with our installation. With our knowledge of how the system worked, it was interesting to see how people made sense of it and how they tried to interact with it. During our lab-evaluation, participants performed a wide variety of movements and gestures in their attempt to get a response from the system. It soon dawned on us that if we have had time to do more iterations of tests and improvements, we would be able to create a quite intricate system with lots of different elements to discover and trigger.

During our public tests at the library, we performed passive observations by posing as students studying at a table near the installation. This allowed us to unobtrusively watch and take notes of how people reacted to and interacted with the installation. But it became a challenge to keep up with the note-taking when there many people interacting with it, so we had to prioritize which observations to record. Another complicating factor was that people would spend such a short time interacting with the installation that we hardly got the chance to start writing before they left. We therefore decided to focus on one person at a time and make sure we could make accurate observations before moving onto the next one. We continually communicated between each other which participants we were observing. This meant that we were not able to take notes on more than half of the people interacting with the installation.

At the Oslo Mini Maker Faire, we were required to actively engage with the audience and show and tell them about the installation. Consequently, our personal observations might be described as participatory. We were actively interacting with the installation alongside visitors, helping them understand how to interact with it. As mentioned in section 5.2.1, we also had some assistance from our supervisor who did passive observations, using the same coding scheme that we had used at the library. This gave us the valuable data we needed for the subsequent analysis.

Interviews The interviews conducted during our lab-evaluations proved very useful for our understanding of the experiences people had with the installation. It was quite convenient to have a table ready to sit down at immediately after the participants were done exploring the installation, allowing us to go straight into the interview and get their first reactions on tape. Our decision to interview the participants in pairs seemed to work very well. The discussion would flow quite effortlessly and the participants would finish each other's sentences, both building on and contradicting what the other said.

In our first two sessions with expert evaluators, we also asked them for their opinion on our chosen approach. They largely agreed that it was a comfortable and good way to get the conversation going. Some even commented that they enjoyed discussing their experiences. But they also warned that there was a high degree of possibility that they in some way or another would influence each other's answers, thereby jeopardising our results. Nevertheless, given our interpretive and phenomenological methodology, and the subjective area under investigation, we were more interested in getting the participants to talk freely about their experiences than to ensure absolute objectivity in their answers. We experienced that the richness of the conversation we had between the four of us around the table far outweighed the downsides. Also, the interaction with the installation was, in all but one session, done in pairs. By separating the participants for the interviews, we envisaged we would not get the same spontaneous reactions as the participants had to each other's statements, thereby losing more than we gained from interviewing them separately.

If we should suggest any improvement to how the interviews were conducted in the evaluation sessions, we think starting the interview by applying video-cued recall as an element in the collection of data, as done by Brigid Costello [26, p.82], when testing the pleasure framework. Video-cued recall simply means videotaping the participants' interactions with the installation, then reviewing the video together with the participants, asking them to comment on their feelings and thoughts of experience. This might have helped even more with getting a deep knowledge of their experience, and also pinpointing events in time, for example exactly when they understood something, when they got bored or frustrated, etc.

It would also have been very interesting to interview some of the participants that used the installation in the two public locations. This would have given us the possibility to gain a deeper insight into the user experiences of the public contexts as well, adding a dimension to the observation data.

PLEX framework The PLEX framework worked very well as a thematic checklist to go through with the participants. By having themes instead of questions for the participants to talk about, we were able to stimulate the participants into open discussions around the themes. They asked us questions about different interpretations of the themes, making it possible for us to gain insight into how they understood the subject. We were also in several cases able to clear up misunderstandings and miscommunication because of the open nature of our discussions, which was also highlighted as something positive about the process by the participants themselves.

As described in section 2.6.2, the PLEX framework expanded on the pleasure framework (Section 2.6.1), which was originally developed to evaluate interactive art. The PLEX framework was intended to be more generally applicable to pleasurable user experiences, adding seven new categories to the pleasure framework. The new categories were *Control, Completion, Eroticism, Nurture, Relaxation, Sadism, and Suffering*. Our findings suggest that particularly *Control* was an important addition to the pleasure framework. When it comes to *Completion, Relaxation,* and *Suffering*, our participants rated the categories as moderately important for their experiences. Lastly, the categories of *Eroticism, Nurture,* and *Sadism* were rated as unimportant or irrelevant for their experiences. This highlights one of the problems of trying to create generalised models to describe and define user experiences; despite making sense for one experience, a category may be irrelevant for another. However, in our experience it was useful to have a list of categories that were not specifically designed with our installation in mind. It enabled us to provoke reactions and discussions about why, and to what extent, the given categories were irrelevant for the experience. Participants would also elaborate on earlier answers in light of those categories. Thus, the fact that the model was not a perfect fit was to some extent beneficial for the discussion.

No model will ever be able to fully describe *user experience* as a general concept. We therefore argue for using user experience models as a toolbox to inform and explore design, not as a defining structure through which all user experiences should be understood. Indeed, Costello and Edmonds stress the importance of understanding the chosen categories of the pleasure framework as a tool to *"help define, describe, and/or identify the characteristics of a play experience"* [24, p.2]. Similarly, Korhonen et.al. underline:

> *...even though the list of playful experience categories is not a scientific representation of the psycho-physiological reality of human experience, it can be used as an aesthetic tool for the design and evaluation of non-utilitarian features of the products that can make the products more engaging, attractive and playful for users.* [25]

In our case, using the PLEX categories during the discussions seemed to push the participants to consider parts of their experience more closely. To us, this meant gaining valuable insights into their experience we might not otherwise have discovered, and thus highlighting the positive and negative aspects of the installation. These insights made us able to iterate on the prototype before the public tests, hopefully resulting in an installation with a greater potential for enjoyable user experiences.

6.1.2 Findings from evaluation sessions and public tests

Enjoyable aspects of the installation

Through the analysis of our evaluation sessions in the private lab context, we located many statements indicating an enjoyable experience. In this section we want to look at aspects of the participants experiences related to the concepts encompassed by the term 'enjoyment', as described in section 2.4.

Fun The installation in itself was described by most as 'fun'. Blythe and Hassenzahl defined fun as a short-lived distraction from everyday life [16], coinciding well with the way the word is used in describing the experience by the participants. But what exactly was fun about the installation? The participants answers points first and foremost to the *exploration* of the installation and its functionality, then secondly, the immediate responses the installation gave to movement and the sensory aesthetic experiences they resulted in.

Pleasure Pleasure was never mentioned directly by the participants, but there were several examples of descriptions of a flow state [19], which can be linked to pleasure [16]. These experiences were described in terms of being 'lost', mesmerized, having a mental break and entering a relaxed 'kind of mode', and the majority of the participants agreed on this being an essential part of their experience. It's worth noting that some of the participants pointed out, both explicitly and implicitly, that this flow-like state disappeared over time, as the participants ran out of elements of the installation to explore.

Play Several of the participants described the installation and the experience as playful. Their descriptions indicated that they placed the experience more in line with the definition of paidia (free-play), rather than ludus (game) (Figure 2.2). The playfulness the installation facilitated for was deemed as very important, and the participants linked it strongly to the exploration part and the open-endedness of experience, but also to the lack of control. The openness of the installation was described as an advantage, in the way that it encouraged interpretation and exploration. The lack of control was described as not important by one participant, as the point is not to steer something, but to 'play around' and getting responses from the system, which resulted in a 'good feeling'. In relation to the concepts of goals, rules and competitive elements of the ludus-part of play, even the self-proclaimed 'competition-focused' participants acknowledged that those concepts were not the point of this installation.

In the playful behaviour there is an oscillation between exploration and play, where play is triggered by learning or discovery and exploration is triggered by boredom [26, 27, 28]. We found multiple instances of this in the way participants described their explorative behaviour which strongly resembles the process of playful behaviour, emphasising the strong relation between playing and exploring:

> *It is just exploring, really. Until you feel you master (the installation) a bit, then it's really exciting and makes you want to continue. You never know if you have explored everything and that's positive, you never reach an end.*

Aesthetics In terms of aesthetics, both the audio and the visuals were described as fascinating, atmospheric, different, beautiful and soothing. The participants thought the combination of the two fit well together and resulted in a coherent expression and created a good ambiance. It was also pointed out in a positive manner that the expression was kept to an abstract nature. That way it became easier to accept the audiovisual expression, in comparison to trying to depict or simulate something concrete.

Exploration As stated several times in this section and earlier in findings (Section 4.8), exploration was the activity and experience deemed the most important successful aspect of the installation. Several of the participants expressed bluntly that exploration *is* the installation. The exploration was fuelled by the responses given by the installation and their abstract, mysterious, unknown nature. Or, to put in other words, the immediate responses to movement and actions, combined with lack of explanation, made the participants curious and eager to investigate. Their descriptions also highlighted one of the common characteristics of the human brain, namely the constant search for patterns and connections, which was described as an essential part of the process of exploring.

Debated aspects of the experience

Discovery, learning and understanding On some aspects of the experience, the participants were quite divided in their opinions, and one of these was the lack of explanation or guidance in the user interface of the installation. This was by the majority highlighted as something positive, as a catalyst for and component of the exploration, but two of the participants found it confusing, frustrating and incomprehensible. One of the participants who were positive to the minimal explanations, still pointed out that an installation like ours would not be suited for people not interested in exploring.

In terms of discovering and learning, it was described as closely connected to exploration, where discoveries came as a result and reward of the exploration. The process of understanding was the challenging part of the installation. When exploration led to discoveries and understanding, the participants had a sense of progress and achievement, giving them motivation to continue exploring. However, the lack of ‘new things’ to discover and explore eventually led to boredom and loss of interest.

Negative aspects of the experience

Progression Progression was an aspect of enjoyable user experience that originally was overlooked by us in the beginning, but which surfaced through the evaluation of the prototype as *the* most important missing aspect of the participants’ experience. As mentioned earlier, Blythe and Hassenzahl link the concept of pleasure to the concept of flow, but they also argue that pleasure can in fact be thought of in terms of progression [16]. In retrospect, this actually comes across as self evident, when comparing our findings to the overlapping definitions of flow and pleasure, as a longer lasting, more meaningful and immersed experience devoted to an activity (Section 2.4).

The participants wanted more depth to the experience. They wanted more to explore, and gradually increasing variation and difficulty. When they felt they had exhausted their possibilities for exploration, they became bored, and this coincided with the earlier mentioned loss of flow state.

Control to create The second most sought after aspect was control, and on this topic the participants of the prototype evaluation was close to unanimous. They expressed frustration over not getting the expected responses from the system, and this put limitations on what they could do. It prevented them from being creative and expressing themselves through the installation, both in terms of visual and audio expression, and this was emphasised as important to them. Some acknowledged that they attained a certain degree of control, but it was expressed that the threshold for gaining this control should be much lower in order to make the installation accessible to more people.

The lack of control linked very strongly to the absence of mastery, and on this point the feedback was quite direct:

> *[The installation] lacks possibility for mastery.*

And:

> *I don’t think I would master it more if I used it for another 20 minutes.*

The only positive feeling described that related to mastery was through exploring and discovering, but even then this process was described as fumbling.

The lack of control highlights the relation between the second- and third- paradigms of HCI, and between usability and user experience. In our phenomenologically situated approach, the focus was on enjoyable user experiences, and not so much on usability and ease of use on a specific level. Also, the explorative and abstract nature of the installation meant that it was difficult to define specific usability criteria for it. This is not to say that control was not a focus in our design, but the lack of precision in the tracking data from the Kinects and our experiential focus led us to design a system that did not need very specific and precise controls. Nevertheless, our findings clearly show that lack of control detracts from the experience. This is in line with our findings in the literature review (Section 2), where usability is described as a prerequisite but no guarantee for good user experiences. It also underlines the importance of both second- and third- paradigm HCI approaches for the overall user experience; neither approach is complete on its own, but must be combined selectively according to the specific design context in order to make the user experience as enjoyable as possible.

Competition and Cooperation Some of participants in the prototype evaluations were self-declared competitive persons, while others were not. The ones describing themselves as competitive, did express a wish for competitive elements when asked for any optional improvements to the installation, although they acknowledged this was not a necessity. As the installation in itself did not contain any competitive elements, these participants admitted to creating their own competitive elements, like trying to 'take' all of their co-participants visual elements and exploring and understanding functionality of the installation before their partner did.

Although competition and cooperation are inherently opposites, they are still closely connected and share some of the same traits. Some participants perceived the experience as a cooperative effort, and all of the participants who were testing in pairs were cooperating in their exploration, learning from each other how the installation worked. Even so, they all considered facilitating for cooperation through the installation itself as something that could improve the experience.

How successful was our design?

Based on the findings of the private evaluation sessions and supported by the observations of the public tests, did we manage to facilitate for an enjoyable user experience, considering our goals (Section 1.1.1) and intentions (Section 4.1) starting this thesis?

Participants found the experience aesthetically pleasing and praised its abstract nature of both audio and video, and complimented the coherent expression, which created a good ambiance. The installation was described as fun, by saying it outright and also through descriptions of their experiences, matching the definitions of fun (Section 2.4.1).

Did we then manage to facilitate an open-ended playful experience? To a certain degree, yes. The experience was open and included no rules at all, except for the 'too close'-zone, signalling participants they were blocking the view of others. It engaged potential users by pulling them into the installation and then letting them interact with it in the way they saw fit. Considering the definition of play as *"free movement within a more rigid structure"* [21, p.304] we would claim to have succeeded. If on the other hand one considers the definition of play [26] where exploring behaviour is *what can* *this object do?* and playful behaviour is *what can I do with this object?*, one could argue we at least did not unlock the full potential of playful behaviour and open-endedness, as we did not provide users with sufficient control to shape their own experience.

As mentioned above, the participants found the installation aesthetically pleasing, and as such it might be described as pleasurable. If on the other hand, one looks at pleasure in terms of progression and flow (Section 2.4.1), it is debatable whether we managed to facilitate this. The overall reports from participants were that they were quite captivated, which, as earlier mentioned, can be seen as a form of flow-state. But this captivation decreased over time as participants ran out of things to explore and discover, leaving them feeling bored and with an expressed craving for further progress. Considering this argument that pleasure is related to flow and is seen as a longer lasting experience than fun, we are in doubt if we can call the experience pleasurable. How long must a flow-state last in order to be considered successful? How long is a lasting experience? According to our intentions (Section 4.1), we meant the installation to be something you would stumble across in a context where exploration and interaction would be a natural behaviour (like at The Science Museum), and that potential users would play around with it for 2-3, and at best 5 minutes before moving on. The time participants of the private prototype evaluation sessions spent interacting with the installation before either becoming bored or being stopped by us, exceeded our expectations by a multiple of three to seven times. However, the private setting of our evaluation sessions was very different from the intended public setting, making it hard to get a good impression of how the duration of use would be in a public context. Based on these mentioned definitions of pleasure and factoring in our intentions (Section 4.1), one might argue both for and against that the installation facilitates pleasurable experiences, but it is difficult to make any definitive claims about how pleasurable the experience was.

It is also debatable whether we managed to give participants the ability to control and create their own experiences. The users of the installation were able to affect it, and gain a certain level of control, but we failed to provide sufficient control to facilitate a creative expression. There were some exceptions to this, but we acknowledge that it would be useful with a lower bar of entry for most users, by either providing more intuitive controls or explaining existing controls better through the user interface. At the Oslo Mini Maker Faire we were providing hints to users of the installation, nudging them in the right direction, which resulted in more engagement. This rise in levels of engagement was also observed when use was demonstrated at the Science Library (Section 5.1.2).

Although we had created an installation that allowed several people to use it simultaneously, we had only vaguely implemented elements that specifically facilitated or required cooperation. As described in section 4.5.2, if any two hands regardless of owner were in approximately the same spot, a lightning bolt flashed horizontally across the screen. Also, the background colour would continually change as a sum-response to all users' positions. Lastly, it was possible to cooperatively control the speed of the music by kneeling down. Given the open-ended and abstract nature of the installation, it is understandable that the participants did not experience any sort of cooperative elements in the installation itself. However, participants cooperated on exploring the installation by directing each other and communicating their 'findings'. The importance of this cooperation for the experience became evident when we observed people interacting with the installation on their own. They would lose interest faster, and be generally more aware of being watched.

This is of course, as everything else concerning user experience, highly subjective. Nevertheless, we would argue that we managed to create an installation that at least was fun, aesthetically pleasing and provided an arena facilitating for a playful experience. We also acknowledge that our installation still has clear potentials for improvement in areas of progression, control and cooperation. If we were to evaluate people's experiences with the installation based solely on an interpretation of their facial expressions, we would have to conclude that the installation was a success, as an overwhelming majority of people either smile or have a fascinated expression on their face when confronted with the installation, both at the Science Library and during the Oslo Mini Maker Faire.

Suggestions for improvement

According to game designer Will Wright, three important aspects of designing a game are engagement, feedback and control [22]. Through our prototype evaluation we learned that our installation to some extent lacked in the areas of control and might lack engagement in terms of progression, if the intention is that the experience should last over time.

A possible solution to mend the feeling of lacking control is to make the interaction with the installation more intuitive, without making it become obvious. As a participant of the evaluation sessions pointed out *"It seems more natural to me that the tools you use to explore the environment are self-explanatory, and that they become aids, rather than having to explore the tools themselves"* - Participant 9.

One reasonably easy fix would be to improve the sense of connection between participants' physical presence and their presence in the visual system. This could be done by heightening the visibility of a participants' hands on screen through making hand representation larger and showing them at all times, not only when active, as shown in figure 4.17 in section 4.5.2. The difference between active and passive hand states could instead be highlighted by markedly changing colour and transparency. Additionally, people in view of the Kinect sensor that has not yet been detected and calibrated, could be shown as a vague outline on screen to signal the connection between the physical space and what happens on screen. When a person then would get calibrated, their outline could be accentuated in the colour, as assigned by the system, and displayed a link from the outline to their position inside the triangle representing the installation's field of view ((1) figure 4.17, section 4.5.2).

A fix that could possibly have a dramatic effect on the feeling of having creative control would be to enable users to better control and modify the musical expression of the installation. But this control would influence the way people moved and interacted, thereby also affecting the interaction with the visuals. It would be practically impossible to control both sound and visuals in a controlled, premeditated and creative fashion, using the same movements. The ability to play notes is already present in the system, but the sounds used in the installation are designed in an atonal way in order to avoid associations with familiar instruments, thereby allowing the visuals to dominate the interaction. Even so, there are certainly ways the sound and musical expression could be made more prominent. For example, by adjusting the sounds played by the users to stand out more from the background music, and maybe give the user control over the pitch of individual sounds, the experience of influence over the sound could be improved.

All of the suggested fixes mentioned above are based on functionality already present in the two systems of the installation, but were toned down or removed because of technical and time limitations.

In order to create engagement through progression, it is very important to give users a gradual sense of accomplishment and mastery over time [22]. Our preliminary thoughts for the installation was that it was supposed to be a richer experience than the final prototype could provide as it was intended to include several more 'modes' to discover and interact with than it currently does, possibly as many as ten. This intention was never realised because of our limited time reserved for development. An alternative solution was presented by one of the participants of the evaluation, who suggested adding puzzle elements to the installation. We think this could very well be a viable option. If designed right, puzzle elements could still enable us to keep the audio and visual systems separate and stateless. The stateless part is important because of the choices made, and issues outlined in section 4.6.1. Most prominent of these reasons is the fact that the systems have no possibility to know which user is which, so creating functionality tied specifically to a user would be near impossible. The advantage of a puzzle is that it does not necessarily *care* who solves it, as long as its conditions are met. Adding such elements could then let us facilitate for several of the aspects sought after by our evaluation participators. It could for example encourage both cooperation and competition in solving the puzzles. It would then add open goals to the system, since by just having a puzzle present, participants would have to choose themselves whether they want to compete or cooperate.

It might not be necessary to both heighten the control aspect of the installation and add more concrete options for progressing. Fixing just one of them might enable and facilitate for other enjoyable aspects of the user experience that neither our team of evaluators or we could not have anticipated.

Context of the evaluation sessions The lab evaluations of the prototype were conducted in a private context; a large closed room without any onlookers apart from us as researchers. Although several participants mentioned being aware that they acted out of the ordinary in the beginning, all participants who used the installation in pairs claimed to feel safe and free to behave in strange and silly ways without any concerns about what others might think of their behaviour.

In this setting we can unfold and explore uninterrupted. - Participant 6

This was not the case for the only participant that conducted the evaluation alone, who felt very self-conscious when using the installation, because of being filmed and observed, and described the lab context as destructive. This participant also had an overall more negative impression of the experience, and had a harder time understanding the interaction, as he had no one to learn from. This suggests to us that our choice to involve pairs of participants was a good way to make the participants feel comfortable with the situation.

6.2 RQ 2: How does different public use contexts influence the user experience?

In this section we will discuss how the user experiences appeared to be affected by the different *public* contexts the installation was tested in. Some of the themes overlap with themes from the preceding section on design and evaluation, but are discussed in terms of how they relate to user experience in a public context.

Kinds of audience The University Science Library was mostly populated by students, lecturers, and other kinds of staff and professionals working in the building. They were there because they had some business there, either going to or from a lecture or the library, hanging out with friends, studying, eating lunch, and so on. Their ages ranged from the late teens to the late sixties, but the vast majority were in their twenties and early thirties.

At the Maker Faire, on the other hand, there was a greater mix of people, ranging from toddlers to grandparents, but with a overweight of children in the pre- and primary-school ages. They mostly arrived in groups, with family members or friends, and were there to experience, learn and enjoy themselves.

Physical space The different physical spaces our installation was exhibited in were quite different. The two locations at the library were exposed and crowded, and in particular the first one. This meant that anyone interacting with the installation would draw attention from not only the immediate surroundings, but also from galleries on the floors above. The sound would naturally draw attention from the surroundings, and given the open layout of the building, it was allowed to disperse throughout the building. Furthermore, as we accidentally discovered when the installation was run without sound output, people did not take notice of the installation at all when it did not produce any sound. This may be explained by the term *display blindness*; people have become so used to all kinds of public displays and advertising that they have become used to ignoring them [62]. Also, *interaction blindness* refers to the fact that it is difficult for people to see whether a given display is interactive. Houben and Weichel [62] has described how display blindness and interaction blindness can be overcome by the use of *curiosity objects*; objects that are designed to draw attention by sparking interest and curiosity. Although not intended specifically as a curiosity object, the sound certainly worked as one, effectively drawing attention to the installation whenever it was triggered.

The space we were assigned at the Maker Faire was somewhere in between the two previous ones. It was partly confined, making it close to impossible for others to observe the installation, or the people interacting with it, from afar. This seemed to give participants a sense of privacy and allowed them to let themselves get more carried away than at the library. Also, our preparation of the installation space with chairs for onlookers to sit on along the sides was very beneficial. It allowed the ones who did not want to try the installation to sit down and relax, but still be able to communicate and take part in the experience with their friends who were interacting with the installation. Several onlookers also eventually got up and tried the installation after having grown curious by watching others.

Breaking social rules and norms A very central concern for many people seem to be a reluctance to appear conspicuous or out of the ordinary in public spaces. As Roto.et.al. has pointed out, *"UX is rooted in a social and cultural context"* [6, p.6]. Most of our interviewees at the prototype evaluation readily admitted that they would restrain their involvement with the installation in a public setting, if they would be willing to interact with it at all. The most central reason they gave for this was the fear of breaking social rules and norms, and of *"behaving like an idiot"*. It was their fear of being perceived by others as doing something people do not normally do in public that would keep them from getting too involved. There were also comments to the opposite effect, indicating that breaking social rules and norms can be liberating and empowering. However, the prevailing notion was that social rules and norms would have a dampening effect on people's level of involvement with such an installation in public settings.

This concern seemed particularly evident at the Science Library. The openness of the location and the number of people in the surrounding area seemed to make people self-conscious and vulnerable when they triggered the installation, particularly if they were alone. At the Maker Faire, there was clearly more headroom for expansive and expressive behaviour. Many of the permanent museum exhibitions are designed for interaction and exploration, and the wide variety of strange projects clearly made people less concerned about how their behaviour would be perceived by others, as this behaviour was expected in this context. Nevertheless, there were examples at both locations of people showing an interest in the installation but being too shy to dare to try it for themselves. But by having the opportunity to watch others interact with it and build an understanding of how it worked, the shyness was often overcome by curiosity, resulting in them engaging with the installation after having observed for a while.

Learning from others Roto et.al. [6, p.6] underlines that user experiences are:

> *encounters with systems – not only active, personal use, but also being confronted with a system in a more passive way, for example, observing someone else using a system*

This was quite evident during our public tests. In fact, people who had the opportunity to observe others using the installation were much more likely to try to interact with it than people who were surprised by it as they walked past. People who unwittingly triggered the installation seemed to be alienated by the sudden appearance of sound and visuals, while people in the surrounding area were able to make sense of the installation from afar, and build curiosity regarding the things they did not understand, eventually leading them to try the installation for themselves. Our findings also seem to indicate that use seems to garner more use. People would queue in the background when the installation was in use, awaiting their turn and observing how the installation worked. However, when the installation was not in use, people in the surrounding area would return their attention to whatever they were doing. This suggests to us that observing others using a product or service is an important aspect of user experiences. By observing others, people have an opportunity to build an understanding of the product or service, and to decide whether it has some interest or value to them.

Cooperation Our findings seem to suggest that interacting with the installation in cooperation with others is more enjoyable than doing so alone. Those who were actively using the installation together with others spent, on average, more than twice as long with the installation as people who were alone. We hasten to add that our time-measurements are not accurate enough to make very strong claims about the duration of use, but to us they underline the general impression we got during our observations. When people were using the installation in groups, they would discuss it with each other and collectively build an understanding of how it worked. They also seemed more at ease with the crowded setting than those that were alone, focusing more on their communication amongst each other. Also, single participants would be visibly more aware of the fact that they were behaving out of the ordinary.

6.2.1 Comparing the quantifiable data of the public contexts

When comparing the quantifiable data from the two public test contexts, one can see some marked differences between the two sites. As mentioned in the findings sections of both contexts, it is important to stress that the data sets are not statistically valid, but serves merely as indicators of how the installation and the context it was exhibited in were perceived.

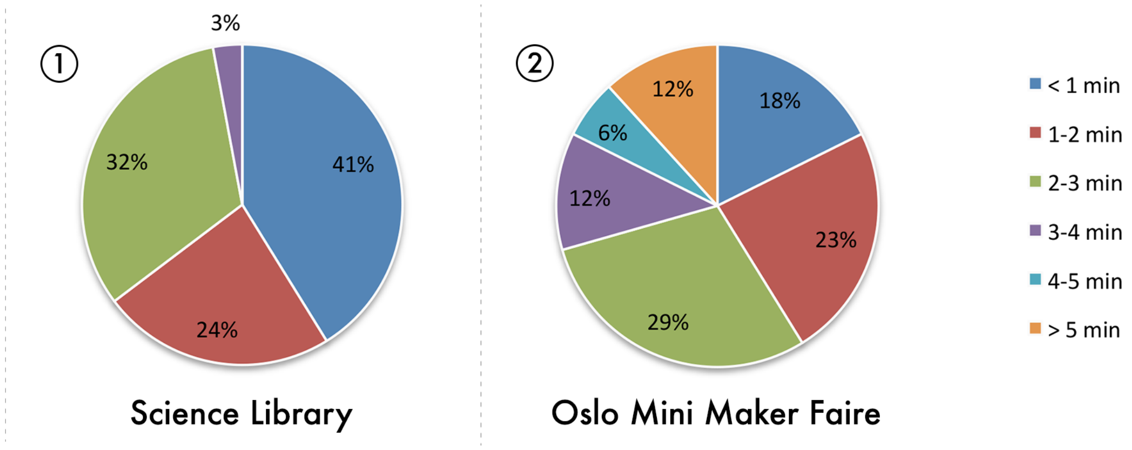

Figure 6.1: Minutes spent interacting with installation by active participants (1) in Science Library and (2) at Oslo Mini Maker Faire.

In terms of time spent by participants interacting with the installation of the two locations, we see the time spent at the Oslo Mini Maker Faire was significantly higher. At the Science Library, no one spent more than three minutes with the installation, 41% spent less than one minute and 72% of the observed spent two minutes or less. At the Maker Faire, the time spent interacting is spread much more evenly across the intervals noted, 59% spent two minutes or more interacting, and some people seen outside the time frame of observations were exceeding the intervals noted significantly.

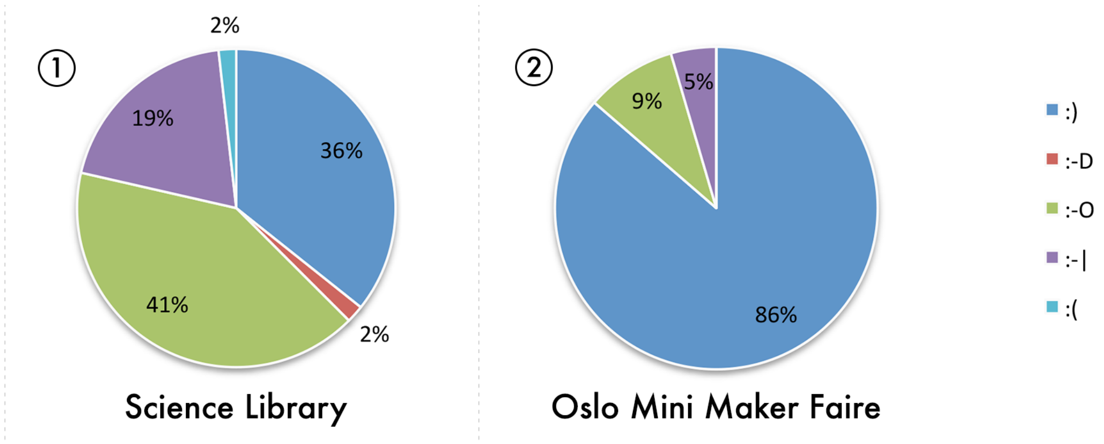

Figure 6.2: Facial expressions of participants (1) in Science Library and (2) at Oslo Mini Maker Faire.

Looking at the distribution of facial expressions observed in the two different contexts, expressions of a positive nature are the predominant ones in both settings, but at the Oslo Mini Maker faire as many as 86% were smiling and even though 5% were noted as indifferent, 95% of the observed were deemed positive.

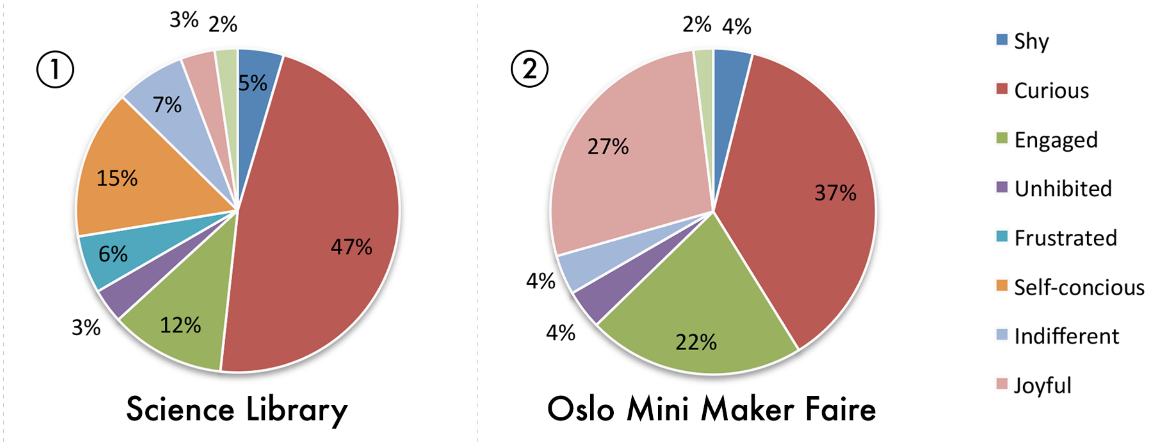

Figure 6.3: Body language of participants (1) in Science Library and (2) at Oslo Mini Maker Faire.

Comparing the observations of body language between the contexts, a high degree of curiosity is observed in both settings, with 47% recorded as displaying a body language suggesting curiosity in the library setting while 37% were recorded at the museum. The most striking difference between the library and the museum contexts was the high percentage of joyfulness (27%) and the low percentage of shyness (4%) of the museum setting, in contrast to the low degree of joyfulness (3%) and high degree of self-consciousness (15%) and shyness (5%) combined (20%). The reason for combining self-consciousness and shyness is that they are very similar traits, and as mentioned in section 5.2.2, self-consciousness was recorded as being completely in control of your own body in the Oslo Mini Maker Faire observations. Seen in retrospect, separating these terms in two coding categories might have been unnecessary, considering their similarities and the fallibility of observation.

6.2.2 Suitability of the contexts in terms of user experience

In our private prototype evaluation, participants would underline that they would be less likely to interact with the installation if it disrupted them on the street or in a shopping center than if they encountered it at a destination like a museum or gallery, as remarked made by one of the expert participants:

> *It would be a lot more socially acceptable in a museum, that you interact with it. I would say my experience would have been much better in a context like that. If the installation were set up in Karl Johan [central shopping street in Oslo] I wouldn't have stopped to check it out, also because I'm going somewhere.* - Participant 9

A reason for this can be the difference between the intended use of the two exhibition spaces. The foyer of the Science Library is a place you pass through on your way somewhere, but the Norwegian Science Museum is a destination in itself. The library foyer is more similar to a 'street' setting, in the way that the installation is unexpected and disrupts passers-by, while at the museum, visitors expect to explore and have an experience. If we also take into account the fact that people spent considerable more time interacting with the installation at the Maker Faire (Figure 6.1), this might support the notion that the Norwegian Science Museum/Oslo Mini Maker Faire was a better suited context for the intended use of the installation, namely facilitating for spending time exploring.

An interesting observation is that the amount of people noted to be fascinated varies significantly between places of observation. At the library, 41% were recorded as fascinated, in contrast to only 9% in the museum context (Figure 6.2). This might suggest, as mentioned above, that people were being disrupted by the unexpected intrusion of the installation at the library.

If we look at the distribution of the observed body language (Figure 6.3), and especially the differences between joyfulness and the combination of self-consciousness and shyness observed in the two contexts, as described in section 6.2.1, it seems that the library context was perceived as a less comfortable one. We think this is due to the 'unnatural' behaviour induced by the installation. Waving their arms in mid-air makes participants of the installation stand out and calls attention to them from people situated nearby who are not aware of what the participants are doing, making many participants uncomfortable. This situation was also predicted by some participants of the private evaluation sessions. They said it was important for them that it was obvious to onlookers what they were doing, if they were to engage in such an installation in a public space.

These suggested effects of breaking social rules and norms and disruption (or surprise) indicated, especially by the observations in the library, are not necessarily to be considered negative. We may consider the installation, as it worked at the time, better suited for the Oslo Mini Maker Faire context, but through alterations to the installation based on feedback from the evaluation sessions, we imagine we could have facilitated a better user experience at the library as well. As earlier suggested, this could be to make the 'tools' or controls more obvious to help the shy/self-conscious but curious understand the basic workings *before* they reach the stage of giving up, preventing potential frustration and embarrassment. To help avoid the perception of 'unnatural' behaviour to onlookers, we could make the connection between participants and their screen presence much clearer, hopefully making it more obvious to the onlookers what participants were doing.

Chapter 7

Conclusion

We were able to design, build, and evaluate a working audiovisual installation. The design process was a multifaceted activity involving research and exploration on many different levels: Technological, conceptual, theoretical, and methodological. We built and tested a range of prototypes to explore different designs, and used the PLEX framework as a guide for designing for enjoyable experiences. Our evaluation of the installation was qualitative, and it was analysed through applying grounded theory techniques. This analysis gave us valuable insights into the user experiences of the participants, telling tales of a fun, fascinating and captivating experience. It also highlighted clear weaknesses of the installation in terms of the lack of control, progression and immediate understanding in the user experience, and spawned ideas and suggestions for improvement.

We exhibited prototypes of various degrees of completeness in four different contexts. We also conducted formal public tests of the final prototype through passive observations in two public contexts: In the foyer of the Science Library of the University of Oslo and at Oslo Mini Maker Faire, held at the Norwegian Science Museum. The findings of these tests highlighted differences in behaviour of both active participants of the installation and passive onlookers of the two different contexts, indicating that context plays an integral role in user experience.

The qualitative and interpretive approach has yielded a richness of data and produced insights and understandings that would not have been attainable with a more quantifiable and positivist approach. However, we acknowledge the relevance of also recording quantifiable data that can be statistically analysed and compared to the qualitative findings. Our quantifiable data was not statistically valid, making it difficult to do a thorough comparison. The little statistical data we had seemed to point in the same general direction as the qualitative findings, and could possibly have strengthened our findings if it had been statistically valid. But if we see our project as a pilot-study, we think that the qualitative approach is very appropriate. It has given us an understanding of the problem area that could be further investigated through more positivist and quantifiable approaches.

We are very satisfied with our approach to the lab-evaluations. The combination of observations, semi-structured interviews, and PLEX framework produced a lot of insightful data into the participants' experiences with our installation. Also, conducting evaluations with pairs of participants made the participants at ease with the situation and able to give more reflected responses to our questions through sparring and discussing with their co-participant. In a project with more time for design and development, we think it would have been useful to conduct evaluation sessions at an earlier stage than we managed. We also think it would be preferable to involve domain experts at an earlier stage because of the unfinished nature of early prototypes, and include amateurs at later stages, when the installation would be more complete.

Our public observations were very informative and useful, but should ideally have been conducted for longer periods of time in order to get more reliable data. It would also have been very interesting to see how the use of the installation would change over time. The coding-scheme we set up beforehand was useful, but could have been better designed. For example, the body language categories of self-consciousness and shyness are interconnected and very difficult to distinguish through observation. Having been through this process we now feel better prepared to form hypotheses that could be explored further through more rigorous tests and experiments.

The public evaluations would also have benefited from a more complete and error-free installation. Our installation had some technical and functional flaws that could have been improved upon. Given enough time, we would have liked to do several more iterations of lab-evaluations and improvements before testing it in a public setting. We think this would have made it easier to interpret people's reactions.

Lastly, we would like to stress that when working with such a subjective phenomenon as user experience, it is important not to be too methodologically stringent. Of course, proper methodological procedures should be followed, but qualitative and quantitative approaches are not mutually exclusive. We think a thorough understanding of user experience needs to build on the strengths of both, and research methods should be chosen based on the problem at hand, rather than according to some elevated principle of how *proper* research is done.

7.1 Future work

We envision there are several possibilities for doing future work based on the topics we have touched upon in this thesis. Particularly, since there is so little research on how use-contexts influence user experiences, we think there is plenty of room for more studies in this area.

We feel that the process we have gone through has given us a very good understanding of the strengths and weaknesses of our installation, as well as how the participants experienced interacting with the installation. If we were to take the research further, we would like to look into ways of doing more rigorous and longer lasting public tests, including more systematic collection of quantifiable data based on the findings from the current research. The current research has given us a number of ideas for improvement of the installation, and we think that through iteratively conducting more lab-evaluations and implementing improvements, we would be able to design an installation that would work well enough to be displayed at a range of public settings over longer periods of time. By using the same installation repeatedly on several different locations, it should be possible to collect both qualitative and quantitative data related to how the different use-contexts influence the user experience.

We also think it would be very useful to either prepare a survey which users of the installation could be asked to fill out, or ask selected users to participate in a short interview. This would allow us to supplement our observations with targeted queries into specific subjects of interest.

Furthermore, in addition to exploring how different public use contexts influence the user experience, we also think it would be interesting to do comparative studies across different cultures. We are curious to know whether the fear of breaking social rules and norms and appearing out of the ordinary when interacting with technology in public contexts is a particularly Scandinavian phenomenon, or whether Brazilian, Italian, or Chinese people would have the same reservations.

We think the experiences we have made and the methods we have used could have the potential to be evolved and refined into a toolbox for evaluating user experience of interactive products some time in the future.

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Appendix A

PLEX survey

Spørreundersøkelse - En leken opplevelse

Denne spørreundersøkelsen handler om dine opplevelser av å bruke Unknown Pleasures. Vi ber deg om å angi i hvor stor grad du opplevde forskjellige følelser eller tilstander under bruk av installasjonen.

Skalaen er som følger:

Ingen	**Liten**	**Moderat**	**Høy**	**Veldig høy**
▢	▢	▢	▢	▢

1. **Ingen opplevelse av nevnt følelse**
2. **Liten opplevelse av nevnt følelse**
3. **Moderat opplevelse av nevnt følelse**
4. **Høy opplevelse av nevnt følelse**
5. **Veldig høy opplevelse av nevnt følelse**

I tillegg ber vi deg vurdere hvor viktig denne tilstanden eller følelsen var for totalopplevelsen. Her er skalaen som følger:

Svært viktig ▢
Middels viktig ▢
Uviktig ▢

Avslappet / avslappende: Opplevelse av ro, avslappethet og stressreduksjon under bruken.

Ingen	**Liten**	**Moderat**	**Høy**	**Veldig høy**
▢	▢	▢	▢	▢

Svært viktig ▢
Middels viktig ▢
Uviktig ▢

Trollbundet: Opplevelse av å glemme andre gjøremål, tid, sted og rom.

Ingen	**Liten**	**Moderat**	**Høy**	**Veldig høy**
▢	▢	▢	▢	▢

Svært viktig ▢
Middels viktig ▢
Uviktig ▢

Kreativ: Opplevelse av å skape noe, eller uttrykke deg på en kreativ måte.

Ingen	Liten	Moderat	Høy	Veldig høy	
▢	▢	▢	▢	▢	**Svært viktig** ▢ **Middels viktig** ▢ **Uviktig** ▢

Sansefornemmelse: En meningsfull opplevelse gjennom sansene.

Ingen	Liten	Moderat	Høy	Veldig høy	
▢	▢	▢	▢	▢	**Svært viktig** ▢ **Middels viktig** ▢ **Uviktig** ▢

Simulering: Opplevelse av simulering / representasjon av virkelighet / 'ekte' opplevelser.

Ingen	Liten	Moderat	Høy	Veldig høy	
▢	▢	▢	▢	▢	**Svært viktig** ▢ **Middels viktig** ▢ **Uviktig** ▢

Utfordring: Opplevelse av at dine ferdigheter blir utfordret og at du må utvikle nye ferdigheter for å mestre situasjonen.

Ingen	Liten	Moderat	Høy	Veldig høy	
▢	▢	▢	▢	▢	**Svært viktig** ▢ **Middels viktig** ▢ **Uviktig** ▢

Spenning: Opplevelse av spenning som følge av en opplevd eller reell fare. (Eks: 'monsteret vil drepe meg', eller 'hvis jeg ikke skynder meg går tiden ut').

Ingen	Liten	Moderat	Høy	Veldig høy	
▢	▢	▢	▢	▢	**Svært viktig** ▢ **Middels viktig** ▢ **Uviktig** ▢

Konkurranse: Opplevelse av seiersfokusert konkurranse mot deg selv, maskinen, eller en eller flere motspillere.

Ingen	Liten	Moderat	Høy	Veldig høy	
▢	▢	▢	▢	▢	**Svært viktig** ▢ **Middels viktig** ▢ **Uviktig** ▢

Lidelse: Opplevelse av frustrasjon, sinne, kjedsomhet, eller skuffelse under bruken.

Ingen	Liten	Moderat	Høy	Veldig høy	
▢	▢	▢	▢	▢	**Svært viktig** ▢ **Middels viktig** ▢ **Uviktig** ▢

Fullføring / måloppnåelse: Opplevelse av å nå et mål, løse et problem / utfordring, eller å fullføre det du hadde til hensikt å gjøre.

Ingen	Liten	Moderat	Høy	Veldig høy	
▢	▢	▢	▢	▢	**Svært viktig** ▢ **Middels viktig** ▢ **Uviktig** ▢

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Kontroll: Opplevelse av mestring, makt, kontroll, ekspertise, virtuositet.

Ingen	Liten	Moderat	Høy	Veldig høy	
▢	▢	▢	▢	▢	**Svært viktig** ▢ **Middels viktig** ▢ **Uviktig** ▢

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Utforsking: Opplevelse av å utforske noe. Et ukjent territorie / verden / mysterium / situasjon / funksjonalitet.

Ingen	Liten	Moderat	Høy	Veldig høy	
▢	▢	▢	▢	▢	**Svært viktig** ▢ **Middels viktig** ▢ **Uviktig** ▢

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Oppdagelse: Opplevelse av å oppdage noe: en løsning, et sted, eller en egenskap.

Ingen	Liten	Moderat	Høy	Veldig høy	
▢	▢	▢	▢	▢	**Svært viktig** ▢ **Middels viktig** ▢ **Uviktig** ▢

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Fantasi: Opplevelse av / innlevelse i imaginære verdener, historier, og karakterer.

Ingen	Liten	Moderat	Høy	Veldig høy	
▢	▢	▢	▢	▢	**Svært viktig** ▢ **Middels viktig** ▢ **Uviktig** ▢

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Sympati: Opplevelse av sympati for noe eller noen.

Ingen	Liten	Moderat	Høy	Veldig høy	
▢	▢	▢	▢	▢	**Svært viktig** ▢ **Middels viktig** ▢ **Uviktig** ▢

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Fellesskap: Opplevelse av vennskap, fellesskap, samhørighet eller identifisering med.

Ingen Liten Moderat Høy Veldig høy Svært viktig ▢
▢ ▢ ▢ ▢ ▢ Middels viktig ▢
Uviktig ▢

Omsorg: Opplevelse av omsorg, kjærlighet, pleie eller empati.

Ingen Liten Moderat Høy Veldig høy Svært viktig ▢
▢ ▢ ▢ ▢ ▢ Middels viktig ▢
Uviktig ▢

Erotikk / sensualitet: Opplevelse av sensuelle eller seksuelle tanker, opphisselse, tenning eller lignende.

Ingen Liten Moderat Høy Veldig høy Svært viktig ▢
▢ ▢ ▢ ▢ ▢ Middels viktig ▢
Uviktig ▢

Sadisme: Opplevelse av destruktiv makt eller makt over andre. Ødelegge for andre.

Ingen Liten Moderat Høy Veldig høy Svært viktig ▢
▢ ▢ ▢ ▢ ▢ Middels viktig ▢
Uviktig ▢

Subversjon: Opplevelse av å bryte sosiale konvensjoner, normer og regler.

Ingen Liten Moderat Høy Veldig høy Svært viktig ▢
▢ ▢ ▢ ▢ ▢ Middels viktig ▢
Uviktig ▢

Omgivelser / kontekst / situasjon: Opplevde du at omgivelsene dine påvirket bruken din (støy, lys, andre tilstedeværende, etc.)

Ingen Liten Moderat Høy Veldig høy Svært viktig ▢
▢ ▢ ▢ ▢ ▢ Middels viktig ▢
Uviktig ▢

Appendix B

PLEX Scores - Prototype evaluation

Plex Score	Total Score	Importance (Total)	User 1 - E	User 2 - E	User 3 - E	User 4 - E	User 5 - E	User 6 - A	User 7 - A	User 8 - A	User 9 - E
Exploration	**32**	**18**	4	4	4	3	3	3	3	4	4
Discovery	**26**	**15**	3	4	2	3	3	3	2	3	3
Control	**18**	**14**	3	2	2	2	2	1	2	2	2
Captivation	**27**	**13**	3	4	4	3	2	3	3	3	2
Sensation	**24**	**13**	3	3	2	3	2	2	3	2	4
Context	**21**	**13**	3	1	3	2	1	3	3	1	4
Suffering	**11**	**12**	1	0	1	1	2	2	1	2	1
Challenge	**21**	**11**	3	2	1	1	3	3	1	3	4
Relaxation	**19**	**10**	2	2	2	3	1	1	2	3	3
Completion	**16**	**10**	1	1	3	2	1	4	1	1	2
Fellowship	**14**	**9**	2	2	0	0	3	1	2	4	0
Creativity	**15**	**7**	2	2	2	2	1	1	2	2	1
Fantasy	**13**	**7**	1	3	1	2	1	0	2	0	3
Subversion	**12**	**7**	0	1	1	2	1	2	3	0	2
Thrill	**8**	**6**	2	3	0	0	1	0	0	0	2
Competition	**11**	**5**	2	3	0	2	1	1	0	0	2
Simulation	**8**	**3**	1	0	0	1	0	2	1	1	2
Sadism	**6**	**3**	1	3	0	1	1	0	0	0	0
Sympathy	**2**	**1**	1	0	0	1	0	0	0	0	0
Nurture	**2**	**1**	0	0	0	0	0	0	1	1	0
Eroticism	**0**	**0**	0	0	0	0	0	0	0	0	0

Importance Score	Total	User 1 - E	User 2 - E	User 3 - E	User 4 - E	User 5 - E	User 6 - A	User 7 - A	User 8 - A	User 9 - E
Relaxation	**10**	0	1	1	2	2	0	1	2	1
Captivation	**13**	1	2	2	2	0	2	2	0	2
Creativity	**7**	0	0	1	2	0	0	2	2	0
Sensation	**13**	2	2	1	1	1	1	2	1	2
Simulation	**3**	0	0	0	1	0	1	0	0	1
Challenge	**11**	2	1	1	1	1	2	1	1	1
Thrill	**6**	1	2	0	1	0	1	0	1	0
Competition	**5**	1	1	0	1	2	0	0	0	0
Suffering	**12**	1	0	2	2	1	1	2	2	1
Completion	**10**	0	0	2	1	2	2	1	1	1
Control	**14**	2	2	1	1	2	1	2	1	2
Exploration	**18**	2	2	2	2	2	2	2	2	2
Discovery	**15**	2	2	2	1	2	2	1	2	1
Fantasy	**7**	1	1	0	2	0	0	1	0	2
Sympathy	**1**	0	0	0	1	0	0	0	0	0
Fellowship	**9**	1	1	1	1	1	1	1	2	0
Nurture	**1**	0	0	0	1	0	0	0	0	0
Eroticism	**0**	0	0	0	0	0	0	0	0	0
Sadism	**3**	1	1	0	1	0	0	0	0	0
Subversion	**7**	0	0	0	1	1	1	2	2	0
Context	**13**	0	1	1	2	1	2	2	2	2

Appendix C

Open coding - Prototype evaluation

Experiences +	Experiences -	Desires	Behavior / Actions	System	Context
Måloppnåelse	**Mål (mangel på)**	**Mål (mangel på)**	**Lage egne mål**	Mål (mangel på)	Trygghet
	Kjedsomhet	**Variasjon (mangel på)**		Variasjon	
Konkurranse	**Konkurranse (mangel på)**	**Konkurranse (mangel på)**	**Lage eget konkurranseelement**		
Sosiale konvensjoner / normer (bryte)	**Sosiale konvensjoner / normer (bryte)**				**Sosiale konvensjoner / normer**
Kontroll	**Kontroll (mangel på)**	**Kontroll (mangel på)**		Kontroll (mangel på)	
Progresjon	**Progresjon (mangel på)**	**Progresjon (mangel på)**	Leting etter mønster (sammenhenger)	Progresjon	Gruppementalitet (hvem og hva ser / tror /mener andre at jeg gjør)
Flyt (Flow)	Selvbevisthet / reservert / sjenert		**Sosiale konvensjoner / normer (bryte)**	**Åpent**	Slippe seg løs / gi slipp på hemninger
Fascinerende	Forvirrende / Uklarhet / Usikkerhet	**Utforskning**	**Utforskning**	Kreativt	**Setting**
Oppdagelse / forståelse / læring		**Oppdagelse / forståelse / læring**		**Spill**	Bevisst på omgivelser
Gøy			**Lek**	**Lek**	Andre deltagere
Ro	**Frustrasjon**			**Abstrakt**	Tilskuere
Stemning				**Gøy**	
God følelse	Irritasjon			Mysterie	
Mestring	Mestring (mangel på)		Kroppslig interaksjon	**Responsivitet**	
Engasjement	Skuffelse		Fysisk utfoldelse	Inngangsterskel	
Utfordring	**Utfordring (mangel på)**		**Felleskap / samarbeid / samspill**	Illusjon	
Felleskap / samarbeid / samspill			Tar lærdom fra andre	Ikke et spill	
Kreativ	Ikke skapende	Mulighet for å skape		Ikke skapende	
Opplevelse forandres over tid	Opplevelse forandres over tid			Varighet / holdbarhet (mangel på)	
Sabotasje				Presisjon	
Spennende					
Illusjon					
Estetikk (lyd / visuelt)	**Støy (visuelt / lyd)**	Estetikk (lyd / visuelt)		**Estetikk (lyd / visuelt)**	
Frustrasjon				**(Utforskning (legger opp til))**	
	Oppdagelse / forståelse / læring (mangel på)			**Oppdagelse / forståelse / læring (mangel på)**	
		Felleskap / samarbeid / samspill (tilrettelegging for)			Felleskap / samarbeid / samspill
Utforsking					
Anderledes					
Surrealisme					
Stress	Stress				
Nysgjerrighet			Nysgjerrighet		
Mysterie					
Inspirasjon					

Hvordan beskriver de installasjonen?	**Hvordan ønsket deltagerne at installasjonen skulle fungere?**	**Hva gjorde deltagerne?**	**Hva ønsket deltagerne å gjøre?**	**Hvordan beskriver deltagerne opplevelsen?**	**Hvordan ønsket deltagerne at opplevelsen skulle være?**	**Hvordan opplevde deltagerne konteksten (LAB / private)?**	**Hvordan mente deltagerne opplevelsen ville være i andre kontekster (PUBLIC)?**
Utforskning	Utforskning	Utforskning	*Utforskning*	Utforskning	Utforskning		
Kontroll (mangel på)	Kontroll		Kontroll	Kontroll (mangel på)	Kontroll		
			Mestring	Mestring	Mestring		
Progresjon (mangel på)	Progresjon		Progresjon	Progresjon (mangel på)	Progresjon		
Mål (mangel på)	Måloppnåelse	Lage egne mål	*Måloppnåelse*	Mål (mangel på)	Måloppnåelse		Mål (mangel på)
		Oppdagelse / forståelse / læring	Oppdagelse / forståelse / læring	Oppdagelse / forståelse / læring	Oppdagelse / forståelse / læring		
Konkurranse (mangel på)	Konkurranse	Lage eget konkurranseelement	Konkurranse	Konkurranse (mangel på)	Konkurranse	Konkurranse	
Utfordring / Utfordring (mangel på)	*Utfordring*			Utfordring / Utfordring (mangel på)	Utfordring		
	Felleskap / samarbeid / samspill	Felleskap / samarbeid / samspill	*Felleskap / samarbeid / samspill*	Felleskap / samarbeid / samspill	Felleskap / samarbeid / samspill	Felleskap / samarbeid / samspill	Felleskap / samarbeid / samspill
		Sosiale konvensjoner / normer (bryte)		Sosiale konvensjoner / normer (bryte)		Sosiale konvensjoner / normer (bryte)	Sosiale konvensjoner / normer (bryte)
				Flyt (Flow)	Flyt (Flow)		
Gøy				Gøy			
Lek		Lek		Lek	Lek		
Spill		Spill		Spill			
Åpent				Åpent			
Abstrakt	Abstrakt						
Estetikk (lyd / visuelt) / Støy	Estetikk (lyd / visuelt) / Støy		*Estetikk (lyd / visuelt)*	Estetikk (lyd / visuelt) / Støy		Estetikk (lyd / visuelt)	
				Frustrasjon			
Variasjon / (mangel på)	Variasjon			Variasjon / (mangel på)	Variasjon		
Responsiv / (mangel på)	*Responsiv*						
						Trygghet	Mangel på trygghet

Appendix D

Quantifiable observations - Public tests

Science Libr

Times (active)

< 1 min	1-2 min	2-3 min	3-4 min	4-5 min	> 5 min
14	8	11	1	0	0

Body language

Shy (SH)	Curious (CU	Engaged (EN)	Unhibited (UN)	Frustrated (FR)	Self-concious (SC)	Indifferent (IN)	Joyful (JO)	Skeptic (SK
4	41	10	3	5	13	6	3	2

Facial expr.

:)	:-D	:-O	:-|	:(
20	1	23	11	1

Maker Faire

Times (all)

< 1 min	1-2 min	2-3 min	3-4 min	4-5 min	> 5 min
3	4	5	2	1	2

Body language

					Ikke som i neg. sel			
Shy (SH)	Curious (CU	Engaged (EN)	Unhibited (UN)	Frustrated (FR)	Self-concious (SC)	Indifferent (IN)	Joyful (JO)	Skeptic (SK
2	19	11	2	0	0	2	14	1

Facial expr.

:)	:-D	:-O	:-|	:(
19	0	2	1	0

Appendix E

Observations - Oslo Mini Maker Faire

Shy - 1, curious – 2, engaged -3, uninhibited – 4, frustrated -5, self-conscious – 6, indifferent -7, joyful -8, sceptic-9

13:50	A boy ca 5 interacting with the system, big movement with his hands, smiling, seems really engaged. (5 minutes)	2,3,8
13:55	A boy, ca 12. More reserved, perhaps shy, then the boy before. Explores carefully. Leaves 13:57 (2min)	1,2
13:56	A man, ca 30 comes in and explores, no particular expression, but keeps on trying for about (2 minutes)	2,9
13:58	A young father and a son ca 7 come in and explore. They both seem fascinated and very happy to explore, however each for themselves. (1 min)	3, 8
13:58	A boy comes in ca 8, explores carefully, but with interest. This makes his friend join. The father and the son who were there in the beginning leave. Few seconds later another 2 boys come in, seeming very curious, but go (out after a few seconds). The boys were mimicking each other when they were all 4 on the floor. The second boy leaves, but the first one stays still a bit longer. (4 minutes) for the first boy.	2,3,8
14:01	2 ladies ca 20 years old try for a few seconds (ca 20-30), while the boy is still in the field. The boy moves very much back and forth in the triangle, the ladies walk away.	7
14:02	Two boys join in , one young, ca 4-5, the other bigger. The boy who was there for a long time leave. The bigger boy explores freely, big movements. The small one mimics after the other one. The bigger boy goes up and down, certainly engaged and curious. Both boys smile the whole time. (2 min)	2,3,8
14:04	A boy aged 4-5 comes in. After a few seconds he is alone. Really curious, smiling. As he leaves, he says ”dette var gøy”	2,3,8
14:08	A mother and a daughter ca 3 years of age try carefully. Perhaps shy. The boy comes back- he is the brother of a little girl. Mother explains to the boy relation between graphics and his movements, music and his movements. The boy is very satisfied. The girl is shy. The boy really explores. Comes too close to kinect and slowly backs up, making huge movements.	1 2,3,8
14:11	The boy goes away. The mother says aloud: dette var skielig gøy! (This was really fun” (3 min)	8
14:11	A man and a baby come in and try. The baby is totally fascinated by colors and graphics. The mother of the baby	2,8

	joins. (1 min)	
14:12	Two girls, looking like students (early 20) smile broadly. Nearly dance in the kinect vision field. They try also to cooperate a bit, they communicate what they want, try all positions within triangle of vision, move up and down, even jump. (2 min).	2,3,8
14:14	A boy comes in. He is obviously fascinated by colors and graphics, (1 min)	2,3,8
14:16	A girl and a boy, ca aged 10 try. They are really researching the field, the girl is dancing, almost break style, very uninhibited, self-conscious, (3 min)	2,3,4,8
14:19	A father and 2 children come in, try for few seconds (ca 30 sec) and leave	7
14:20	A young man and a girl in 20ies try. The system breaks down. Wait for it to reboot. They seem not to mind and continue exploring with big smiles on their faces. System breaks down again, reboot again- takes just some seconds. They continue. Cooperate. They seem to have fun. The graphics are very nice (same style of course, but mixture much richer). Both are smiling and clearly enjoying the experience. (5 minutes)	2,3,4,8
14:26	A lady in 20ies tries. Smiles and says Cool. Talks aloud"Do I influence the music" "oh yes, I see" Tries carefully. Says "cool" again and leaves. (1min)	2,3,8
14:31	A grandmother tries. She has 2 grandchildren. She is ca 60, and the kids are young. They all smile. The grandfather comes in for a moment. They all leave .14:32 (2 min)	2,8

In addition, Mathilde tried, several times, very positive feedback.
Duration of observation 42 minutes. 2 observants, 1 expert in sensory perception.
People observed 33, aged from ca 1-somwhere in the 60ies. Average time over 2 minutes.

Appendix F

List of inspirational resources

Links from our inspirational research tumblr (http://robotcalmingnews.tumblr.com/). Links appearing here are ordered in reverse from appearance on the tumblr-page, showing the oldest first. All links included were alive May 7th, 2013.

- **TEDxVancouver - Jer Thorp - The Weight of Data**
  http://www.youtube.com/watch?v=Q9wcvFkWpsM
- **All Eyes On You [openFrameworks, Javascript, Kinect, Arduino]**
  http://www.creativeapplications.net/openframeworks/all-eyes-on-you-openframeworks-javascript-kinect-arduino/
- **Puppet Parade [openFrameworks]**
  http://www.creativeapplications.net/openframeworks/puppet-parade-openframeworks/
- **Chaotic Moon Labs' Board of Awesomeness**
  http://www.youtube.com/watch?v=n_xz7nX-Dzg
- **CES 2012 Keynote: The Magic of Kinect with Sesame Street**
  http://www.youtube.com/watch?v=FOOi3buMmTs
- **Kinect Hand Detection**
  http://www.youtube.com/watch?v=tlLschoMhuE
- **Telenor Globe interactive installation**
  https://vimeo.com/23796112
- **Kinect music prototype**
  https://vimeo.com/33022028
- **Kinect Projection mapping with box2D physics**
  http://www.youtube.com/watch?v=4V11V9Peqpc
- **"unnamed soundsculpture" by Daniel Franke & Cedric Kiefer / Kinect**
  http://www.creativeapplications.net/processing/unnamed-soundsculpture-by-daniel-franke-cedric-kiefer-kinect-processing/

- **design I/O**
  http://design-io.com/

- **"Difluxe" by Avoka Production – Upsetting the balance of a microcosm / Cinder**
  http://www.creativeapplications.net/cinder/difluxe-by-avoka-production-upsetting-the-balance-of-a-microcosm-cinder/

- **AHNE - Audio-Haptic Navigation Environment**
  https://vimeo.com/28447850

- **Monkey Business**
  http://www.youtube.com/watch?v=pWAud-9jNJY

- **Selected Works, 2007-2011**
  https://vimeo.com/31278330

- **MK12 // Stranger Than Fiction: Opening HD**
  http://www.youtube.com/watch?v=WDwTQ57YyzI

- **Kinect Conception : Modulus**
  https://vimeo.com/36699398

- **Kinect Conception : Matieres Choregraphiques**
  https://vimeo.com/36699936

- **Deluge**
  http://vis.bengler.no/deluge

- **Unity3D And Microsoft Kinect? Hell Yeah!**
  https://vimeo.com/19299107

- **As Above - So Below**
  https://vimeo.com/31610424

- **Roberto Fazio - Artistic residency/workshop on 3d Architectural Interactive Mapping + Kinect in VVVV**
  https://vimeo.com/27061344

- **Laser Graffiti**
  http://www.youtube.com/watch?v=sU6mVgDAod4

- **Graffiti Analysis**
  http://graffitianalysis.com/

- **Video: Bizarre Magnetic Ferrofluids Will Blow Your Mind**
  http://www.wired.com/wiredscience/2012/04/ferrofluid-videos/?pid=3598

- **Digital Wayang with Kinect**
  http://antoni.us/post/4541375845/digital-wayang-with-kinect

- **Generative tool to create visual elements for an identity system**
  https://vimeo.com/40301390
- **RGBDToolkit - DSLR + DEPTH FILMMAKING**
  http://rgbdtoolkit.com/
- **La Gabbia - auroraMeccanica - videoinstallazione interattiva**
  https://vimeo.com/25831269
- **Kinect Graffiti /Ribbon Test**
  https://vimeo.com/20866868
- **Fabricate Yourself**
  http://www.youtube.com/watch?v=6PWaU4u5QVo
- **Kinect Graffiti /Mockup 2**
  https://vimeo.com/20559686
- **Kinect Graffiti™**
  https://vimeo.com/24665893
- **Predator: Camera That Learns**
  http://www.youtube.com/watch?v=1GhNXHCQGsM
- **Red Bull Music Academy 2008 Barcelona**
  https://vimeo.com/album/30350
- **MULTITOUCH-BARCELONA.COM - NATURAL INTERACTION PROJECT**
  http://www.multitouch-barcelona.com/blog/?page_id=385
- **Make the Line Dance**
  https://vimeo.com/21308228
- **Virtual Drawing**
  https://vimeo.com/33776626
- **SYNAPSE for Kinect**
  http://synapsekinect.tumblr.com/
- **PuShy - a tactile sonic interface**
  https://vimeo.com/31644503
- **KacheOut @ Create Denver Week 2012**
  https://vimeo.com/43230920
- **Paik times five**
  https://vimeo.com/43218015
- **Minority Report Software For Kinect**
  http://www.kinecthacks.net/minority-report-software-for-kinect/

- **V Motion Project – Part I: The Instrument**
  http://www.custom-logic.com/blog/v-motion-project-the-instrument/
- **V Motion Project – Part II: The Visuals**
  http://www.custom-logic.com/blog/v-motion-project-part-ii-the-visuals/
- **V Motion Project Tech – How We built it**
  http://fugitive.co.nz/v-motion-project-tech-how-we-built-it
- **Leap Motion**
  https://www.leapmotion.com/
- **Firewall – Stretched sheet of spandex as a visual instrument**
  http://www.creativeapplications.net/maxmsp/firewall-stretched-sheet-of-spandex-as-a-visual-instrument/